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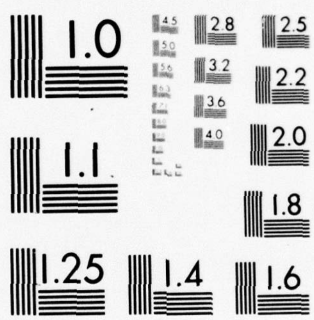

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CR-189

Documentation Report to Support the Analysis for Management of Recruiting Resources and Operations (AMRRO) System

Project Manager

Daniel F. Huck

Principal Investigator

Jerry Allen

Assisted by:

Jack James
Alison Crews
Ronald Arms
Jose Imperial

Prepared for:

US Army Recruiting Command

Contract: DAKF15–76–C–0144

June 1977

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WESTGATE RESEARCH PARK, McLEAN, VIRGINIA 22101

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the following programs both methodologically and operationally:

1) The Optimal Budget Allocation Model (OBAM),
2) The Optional Recruiter Allocation Model (ORAM); and
3) The MERGE/BMD Time Series Regression Model.

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1 INTRODUCTION

1.1 SYSTEM BACKGROUND

The following report describes a manpower planning system that was developed to assist the Army in improving its recruiting programs. This system performs three basic functions:

1. The system identifies factors that significantly influence the number of supply limited accessions that the Army will recruit, and identifies the estimated relationship that exists between these factors and the estimated accessions.

2. Given restrictions on its accession resources, the system indicates the amount of resources that should be devoted to various budget activities (e.g., it determines the amounts of money that should be allocated to advertising, recruiters and recruiter assistants).

3. Once the number of recruiters and canvassers that are to be made available during the year are estimated, the system proceeds to optimally allocate them, by DRC, throughout the country.

The system described in this report is composed of three types of models. Detailed summaries of these models are provided in the next section of the current chapter, and detailed descriptions are provided in Chapters 2, 3 and 4. The current section is devoted to a brief overview of this material.

The first class of models consist of five nonlinear optimal budget allocation models. Choice of a model will depend on the analyst's view of which model's assumptions most closely describe the situation at hand. Subject to budgetary constraints, which are exogenously determined, all models will indicate how available resources should be allocated among competing programs, to yield maximum returns on investment. In general, the budget allocations obtained will differ with the model chosen.

The second type of model is concerned with optimally distributing recruiters and canvassers throughout the United States, by DRC. This model can be used to study how accessions of supply limited cohorts

(i.e., mental category I-IIIA, high school graduate males) vary with changing economic and social conditions, and with changes in the service's recruiting activities. The number of recruiters and canvassers available for allocation will be determined by the optimal budget allocation model discussed above.

The third type of model is a stepwise time series regression model that seeks to estimate the number of supply limited contracts that the service can expect, given past and/or present values for such variables as the number of recruiters on station, the national unemployment rate (deseasonalized), the existence of enlistment incentive programs, and the existence of relevant policy constraints on service accessions. This model is useful in identifying factors that significantly influence yearly accessions, and can be used in formulating the objective functions of the optimal recruiter and budget allocation models.

1.2 SYSTEM COMPONENTS

Optimal Budget Allocation Model (OBAM)

The optimal budget allocation model, discussed in detail in Chapter 2, is a nonlinear optimization model. The objective of the model is to maximize return from money invested subject to specified budget constraints. The model projects accessions on a national level and is constrained by limits on activities such as recruiting and advertising.

The model produces reports that illustrate the expected accession mix of high school and non-high school graduates and mental group IVs. High school graduates in mental groups I-III are considered explicitly by the model. Non-high school graduate and mental group IV accessions are computed on the assumption that they are, as a matter of policy, demand limited.

This OBAM was developed in the course of other studies on recruiting. It was determined that this was a prime candidate for inclusion in the Market Analysis Subsystem. Since this was not part of the study entitled Analysis for Management of Recruiting Resources and and Operations, it is possible that the model may not be as refined as required for certain recruiting analyses.

Optimal Recruiter Allocation Model (ORAM)

The optimal recruiter allocation model, discussed in detail in Chapter 3, is of the nonlinear optimization type. Given national, regional, combat arms and term-of-service goals for the accession groups, this model searches for minimum allocation of recruiters and canvassers throughout the country. A full range of optimal solutions are produced by the model, and these enable it's users to investigate the effects that factors, such as future unemployment rates, have on their planning.

Output produced by ORAM consists of report evaluations which are based on the optimal recruiter allocations that it generates. These evaluations are conducted on the DRC level, and provide the following information:

- DRC identification;
- DRC number;
- Number of recruiters on station;
- Number of canvassers (where applicable);
- Number of accessions (total);
- Number of accessions by cohort groups

In addition, subtotals by region, national totals, regional percentages and national summaries are also provided.

MERGE/BMD Time Series Region Model

The MERGE component of the MERGE/BMD system has the task of handling data; the BMD portion of this system consists of a stepwise regression model for processing MERGE's output. By combining MERGE with BMD, large scale time series regression problems can be formulated with a minimum of program preparation. Objectives for the time series regression model are twofold:

- To examine recruiting factors which influence service enlistments, based on a month-by-month analysis of enlistments.
- To forecast enlistments on a monthly basis into the future.

Model output is on a regional, rather than national level and can involve either numbers of accessions or enlistment contracts.

2 BUDGET ALLOCATION MODEL

2.1 INTRODUCTION

A major concern in any market is the investment required to stimulate the "purchase" of a product. The U.S. Army is concerned with the potential demand for Army careers that may be expected from its investment in recruiting and advertising programs. The question that one must be able to answer is the allocation of budget dollars in various programs that maximize the return for each dollar invested. This chapter considers five possible models, and the methodology for each form. One model (multiplicative exponential) has been included in the market information subsystem.

2.2 METHODOLOGY FOR OPTIMAL BUDGET ALLOCATION MODEL (OBAM)

Several models, all of which have decreasing rates of return for large budgets, were considered as potential candidates for part of an optimization study. The general character of the optimal returns per total budget is represented by Fig. 2.1.

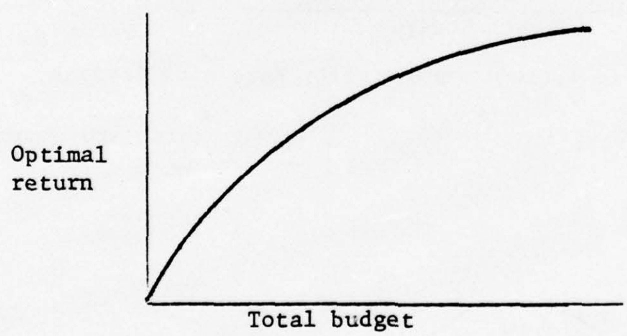

Fig. 2.1—Variations in Optimal Return with Changes in the Budget

Typical optimal allocations of resources to the supporting programs needed to achieve the return are represented by Fig. 2.2.

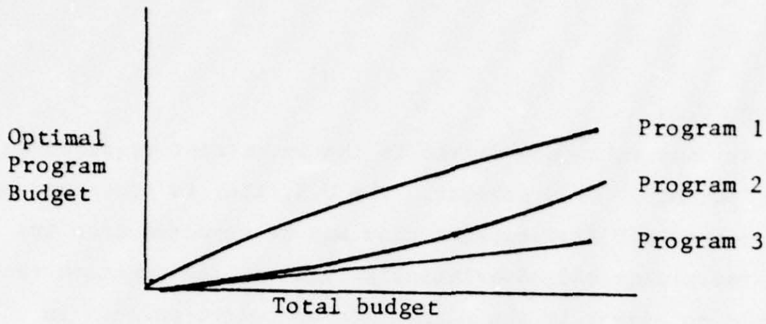

Fig. 2.2—Variations in Optimal Budget Allocations with Changes in the Budget

Typical optimal productivity curves of optimal rates of return per unit budget spent are represented by Fig. 2.3.

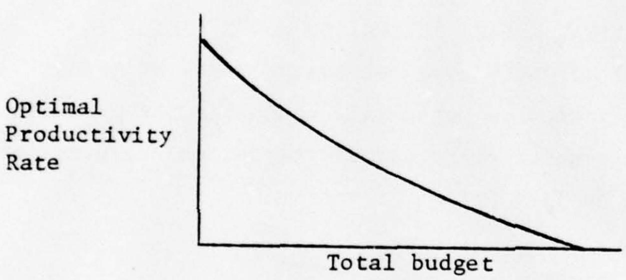

Fig. 2.3—Variations in Optimal Productivity Rate with Changes in the Budget (1)

Some models may have optimal productivity curves which are characterized by Fig. 2.4.

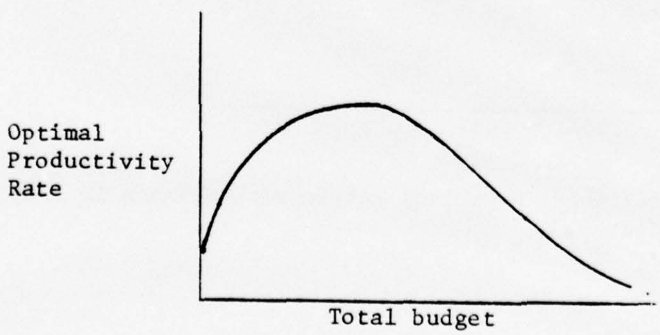

Fig. 2.4—Variations in Optimal Productivity Rate with Changes in the Budget (2)

All curves appearing in Figs. 2.1 through 2.4 are optimal in the sense that the budget constrained problem (P) is solved. The statement of this problem is as follows:

Problem P:

$$\underset{X_1,\ldots,X_p}{\text{maximize}}\ F(X_1,\ldots,X_p) \qquad \text{(return function)}$$

Subject to constraints

$$\sum_{i=1}^{p} X_i = B \qquad \text{(total budget constraint)}$$

$$X_i \geq 0 \quad i = 1,\ldots,p \qquad \text{(no negative budgets)}$$

where

X_i is the budget allocation to program i and p is the total number of programs.

The Lagrangian conditions for a constrained maximum of F are:

$$\frac{\partial L}{\partial X_i} = 0 \ (i=1,\ldots,p) \text{ where } L = F + \lambda\,(B - \sum_{i=1}^{p} X_i)$$

provided the total budget constraint is binding on the optimal solution.

Five different models for F have been considered and the associated optimal solutions have been written down. For reference, F is indexed by $_n$ according to the following convention:

Models F_n	Model Abbreviation	Name of Model	Mathematical Form
F_1	CD+	Cobb-Douglas Additive	$F_1 = \sum_{i=1}^{p} A_i X_i^{B_i}$
F_2	CDX	Cobb-Douglas Multiplicative	$F_2 = A \prod_{i=1}^{p} X_i^{B_i}$
F_3	EXP+	Additive exponential	$F_3 = \sum_{i=1}^{p} A_i(1-e^{-B_i X_i})$
F_4	EXPX	Multiplicative exponential	$F_4 = A \prod_{i=1}^{p} (1-e^{-B_i X_i})$
F_5	EXPXS	Square root multiplicative exponential	$F_5 = A \prod_{i=1}^{p} 1 - (1+B_i \sqrt{X_i})e^{-B_i \sqrt{X_i}}$

Remark: The expression in the parentheses was used as part of an objective function in reference (1) and is inserted here.

Two of the models CD+ and EXP+ are additive, i.e., returns from each program i are considered separately and then together to form the return. The remaining three models are multiplicative and represent the type of return which depends on a contribution from every supporting program.

Parameters

The parameters $A_1,\ldots,A_p$; $B_1,\ldots,B_p$ are estimated in this paper for purposes of illustration using point values for returns, budgets, and marginal productivities. The minimum amount of information needed to "fit" the models (i.e., determine the parameter values) is 3p for the additive models and 2p+1 for the multiplicative models.

Determining the Model Parameter Values (using minimum information)

Additive models

$$F = \sum_{j=1}^{p} A_j f_j \quad \text{where } f_j \text{ depends only on } X_j \text{ and the value of the parameter } B_j$$

Input information

base point budget	$\overline{X}_1, \ldots, \overline{X}_p$	
Base point marginal productivities	$v_1, \ldots, v_p$	3_p values
base point return by program	$a_1, \ldots, a_p$	

Solve the following 2_p equations for A_i B_i (the equations are in

in general transcendental).

$$\frac{\partial F}{\partial X_i} = A_i \frac{\partial f_i}{\partial X_i} = v_i \qquad A_i f_i = a_i \quad \text{provided } X_i = \overline{X}_i$$

combining the above equations yields an equation to be solved for B_i

$$\frac{\partial f_i}{\partial X_i} - f_i \left(\frac{v_i}{a_i}\right) = 0 \qquad \text{solve for } B_i \quad (i=1,\ldots,p)$$

followed by the equation in A_i

$$A_i = \frac{a_i}{f_i} \quad \text{where } f_i \text{ is evaluated at } \overline{X}_i,\ B_i$$

Example - Additive exponential model

Let $F = A_1\left(1 - e^{-B_1X_1}\right) + A_2\left(1 - e^{-B_2X_2}\right)$

Solve for B_i, A_i the equations

$$B_i e^{-B_1 \overline{X}_i} - \left(1 - e^{-B_i \overline{X}_i}\right)\left(\frac{v_i}{a_i}\right) = 0 \qquad i = 1,2$$

$$A_i = \frac{a_i}{\left(1-e^{-B_1 \overline{X}_i}\right)}$$

Multiplicative Models

$F = A \prod_{j=1}^{p} f_j$ where f_j depends only on X_j and the value of the parameter B_j

Input information

base point budget $X_1, \ldots, X_p$

base point marginal productivities $v_1, \ldots, v_p$

base point return a

Solve the following p+1 equations for $A, B_1 \ldots, B_p$

$$\frac{\partial F}{\partial X_i} = \frac{F}{F_i} \frac{\partial f_i}{\partial X_i} = v_i \qquad \text{where } X_i = \overline{X}_i$$

or equivalently since $a = A \prod_{j=1}^{P} f_j (\overline{X}_j)$

$$\frac{\partial f_i}{\partial X_i} - \frac{v_i f_i}{a} = 0 \qquad i = 1, \ldots, p$$

$$A = \frac{a}{\prod_{j=1}^{p} f_j} \qquad \text{where } f_i \text{ is evaluated at } \overline{X}_i \; B_i$$

Example - Cobb-Douglas Multiplicative Model

Let $F = A X_1^{B_1} X_2^{B_2}$ i.e. $f_j = X_j^{B_j}$ and $a = A \overline{X}_1^{B_1} \overline{X}_2^{B_2}$

Solve for B_i, A the equations

$$B_i \bar{X}_i^{B_i - 1} - \frac{v_i}{a} \bar{X}_i^{B_i} = 0 \quad i = 1,2$$

or

$$\left(\frac{B_i}{\bar{X}_i} - \frac{v_i}{a} \right) \bar{X}_i^{B_i} = 0$$

since $X_i \neq 0$

$$B_i = \frac{v_i \bar{X}_i}{a} \qquad i = 1,2$$

and thus

$$A = \frac{a}{\bar{X}_1^{B_1} \bar{X}_2^{B_2}}$$

Note in this example the equations in B_i are in closed form and a direct solution can be found.

<u>Solving for the Lagrangian Stationary Conditions</u>

Solve $\frac{\partial \mathcal{L}}{\partial X_i} = 0$ where $\mathcal{L} = F + \lambda \left(B - \sum_{i=1}^{p} X_i \right)$ (Lagrangian stationary conditions)

<u>Additive Models</u>

$$\frac{\partial F}{\partial X_i} = \frac{\partial f_i}{\partial X_i} = \lambda$$

<u>Example</u> - Additive Exponential Model

$$F = \sum_{j=1}^{p} A_j \left(1 - e^{-B_j X_j} \right)$$

$$\frac{\partial F}{\partial X_i} = A_i B_i e^{-B_i X_i} = \lambda$$

$$X_i^* = \frac{1}{B_i} \ell n \frac{\lambda}{A_i B_i} \quad \text{Provided } \frac{\lambda}{A_i B_i} \leq 0 \text{ i.e., } X_i^* \geq 0$$

Multiplicative Models

$$\frac{\partial F}{\partial X_i} = \frac{F}{f_i} \frac{f_i}{X_i} = \lambda$$

or equivalently

$$\frac{\partial f_i}{\partial X_i} \frac{1}{f_i} = \frac{\lambda}{F} = k$$

$$\frac{\partial f_i}{\partial X_i} - k f_i = 0$$

Example - Square Root Multiplicative Exponential Model

$$F = A \prod_{j=1}^{2} \left(1 - (1+B_j \sqrt{X_j}) e^{-B_j \sqrt{X_j}} \right)$$

$$\frac{\partial f_i}{\partial X_i} - k f_i = \frac{B_i^2}{2} e^{-B_i \sqrt{X_i}} - k\left(1 - \left(1 + B_i \sqrt{X_i}\right) e^{-B_i \sqrt{X_i}}\right) = 0$$

Note that in this model the solution X_i^* for specified k is not explicit. Recursive methods are necessary to solve the equations.

Sketch of Optimal Solutions to the Five Models

A brief sketch of the optimal solutions to problem P for each model follows:

Optimal Solutions to Models

Optimal values of the models are denoted by F^*

Optimal solutions of the models are denoted by X_i^* $i=1,\ldots,p$

Optimal productivities of the models are denoted by λ^*

The change in optimal program solutions with total budget is denoted by $\frac{dX_i^*}{dB}$.

Cobb Douglas Additive Model F_1

$$X_i^* = \left(\frac{\lambda}{B_i A_i}\right)^{\frac{1}{B_i - 1}} \quad \underline{\text{i.e.,}}\ \lambda^* = A_i B_i X_i^{*\,B_i - 1} \quad i=1,\ldots,p$$

$$F_1^* = \sum_{i=1}^{p} A_i X_i^{*\,B_i}$$

$$\frac{dX_i^*}{dB} = \frac{\frac{dX_i^*}{d\lambda}}{\frac{dB}{d\lambda}}$$

$$B = \sum_{i=1}^{p} X_i^*$$

Cobb-Douglas Multiplicative Model F_2

$$X_i^* = \frac{B_i}{k} \quad \text{where} \quad \lambda^* = k\, F_2^*$$

$$F_2^* = \frac{A \prod_{i=1}^{p} B_i^{B_i}}{\prod_{i=1}^{p} k^{B_i}} \qquad (i=1,\ldots,p)$$

$$B = \frac{\sum_{i=1}^{p} B_i}{k} \qquad \frac{dX_i^*}{dB} = \frac{B_i}{\sum_{i=1}^{p} B_i}$$

Additive Exponential Model F_3

$$X_i^* = \begin{cases} \frac{1}{B_i} \ln A_i B_i - \frac{1}{B_i} \ln \lambda & \text{if } \lambda < A_i B_i \\ 0 & \text{otherwise} \end{cases}$$

$$F_3^* = \sum_{i=1}^{p} A_i - \lambda \sum_{i=1}^{p} \frac{1}{B_i} \qquad \lambda^* = A_i B_i \, e^{-B_i X_i^*}$$

$$B = \sum_{i=1}^{p} \frac{1}{B_i} \ln A_i B_i - \ln \lambda \left(\sum_{i=1}^{p} \frac{1}{B_i} \right) \qquad i=1,\ldots,p$$

$$\frac{dX_i^*}{dB} = \frac{\frac{1}{B_i}}{\sum_{i \in I} \frac{1}{B_i}} \qquad I = \left\{ i \mid X_i^* > 0 \right\}$$

Multiplicative Exponential Model F_4

$$X_i^* = \frac{1}{B_i} \ln \left(1 + \frac{B_i}{k} \right) \qquad \text{where} \qquad \lambda^* = k \cdot F_4^*$$

$$F_4^* = \frac{A}{\prod_{i=1}^{p} \left(1 + \frac{k}{B_i} \right)}$$

$$B = \ln \prod_{i=1}^{p} \left(1 + \frac{B_i}{k} \right)^{\frac{1}{B_i}} \qquad \frac{dX_i^*}{dB} = \frac{\frac{1}{k+B_i}}{\sum_{i=1}^{p} \frac{1}{k+B_i}}$$

Square Root Multiplicative Exponential Model F_5

Solve for X_i^*

$$\left[k\left(1+B_i\sqrt{X_i^*}\right)+\frac{B_i^2}{2}\right]e^{-B_i\sqrt{X_i^*}} - k = 0$$

where $\lambda^* = k\,F_5^*$

$$\lambda^* = \frac{A}{2}\left(\prod_{i=1}^{p} B_i\right)^2 e^{\sum_{i=1}^{p} B_i\sqrt{X_i^*}}\,(2k)^{-p+1}$$

$\frac{dX^*}{dB}$ is not available in explicit form.

APPLICATION

An exercise which compares the four models using a base point described by reference (2), pages 54 and 55, is presented here. The input information is as follows: (Tables 2.1 and 2.2).

Table 2.1

Input Values

	BASE POINT			
Program	Program Index	Accessions	Productivity	Budget
Recruiter Assistants and Canvassers	1	50000*	700	20.4
Print Media	2	50000*	710	13.0
General Recruiting	3	50000*	210	90

*150,000 was used for the multiplicative models

The parameter values defined for the four models are as follows:

Table 2.2

Parameter Values

Parameters Values ↓ / Model →	CD+	CDX	EXP+	EXPX	EXPXS
A_1	21131.95264	—	56676.906	—	--
A_2	31141.25146	—	53327.027	—	--
A_3	9125.703117	—	61057.220	—	--
A	—	54529.97061	—	162061.6	172456.7643
B_1	.2856	.0952	.10483883	.180407655	1.078554806
B_2	.1846	.06153333	.21341263	.326869851	1.538629790
B_3	.378	.126	.018985865	.0367116148	.465569754

Table 2.3

Model Solutions at Budget Level 123.4 — $M

B	X_1^*	X_2^*	X_3^*	B	Accessions F^*
Base Point	20.4	13.0	90.0	123.4	150,000
Model ↓					
CD+	53.39	30.73	39.22	123.36	160,952
CDX	41.57	26.87	55.02	123.46	157,760
EXP+	29.43	17.50	76.46	123.40	152,901
EXPX	25.32	15.78	82.17	123.28	151,268
EXPXS	28.16	17.44	77.78	123.38	152,621

and Operations, it is possible that the model may not be as refined as required for certain recruiting analyses.

Table 2.4

MODEL DIFFERENCES FROM BASE POINT ALLOCATIONS

	ΔX_1	ΔX_2	ΔX_3	ΔAccessions
Model				
CD+	32.99	17.73	-50.78	10,952
CDX	21.17	13.87	-34.98	7,760
EXP+	9.03	4.50	-13.54	2,901
EXPX	4.92	2.78	- 7.83	1,268
EXPXS	7.76	4.44	-12.22	2,621

RESULTS OF MODEL COMPARISON

The optimal solutions of the base point appear in Table 2.3. Table 2.4 gives the optimal readjustment to program budget allocations at the base point budget of 123.4 million dollars.

CONCLUSIONS

Considerably different program budget allocations result from using different models. Except for the Cobb-Douglas additive model, all models allocated the most funds to general recruiting (program 3) followed by recruiter assistants and canvassers (program 1) and print media (program 2). The Cobb-Douglas additive model, however, allocated more funds to program 1 than program 3.

The types of optimal solutions that each of the models produces should, perhaps, be considered as a factor in the selection of the particular model to be used in a given situation. For example, the Cobb-Douglas multiplicative model yields program solutions that are always a fixed percent of the total budget allocated, no matter what the total budget is. The Cobb-Douglas solutions were more clustered than the exponential solutions in the exercise here. Table 2.5 gives the limiting percent of program budgets as the total budget increases. The multiplicative exponential had the greatest divergence in program percent allocations.

It should be noted that the base point allocation, although not optimal, was least displaced by the exponential type models (Table 2.4).

LIMITING VALUES FOR OPTIMAL PROGRAM ALLOCATION

As the total budget B is made large, the optimal budget allocations to the programs X_i^* approach limiting fixed percentages of the total budget. The percentages differ for each model and are functions of the parameter values. The limiting percentages are as follows:

CDX $$X_i^* = 100 \frac{B_i}{\sum_{i=1}^{p} B_i}$$

CD+ $$X_i^* = 100 \frac{(B_i A_i)^{\frac{1}{1-B_i}}}{\sum_{i=1}^{p} (B_i A_i)^{\frac{1}{1-B_i}}}$$

EXP+ and EXPX $$X_i^* = 100 \frac{\frac{1}{B_i}}{\sum_{i=1}^{p} \frac{1}{B_i}}$$

EXPXS $$X_i^* = 100 \frac{B_i^{-2}}{\sum_{i=1}^{p} B_i^{-2}}$$

For the values of the parameters of the five models the limiting percent allocation of the total budget is shown in Table 2.5.

Table 2.5

Percent of Total Budget Allocation

Model	X_1^*	X_2^*	X_3^*
CD+	27.06	5.63	67.29
CDX	33.67	21.76	44.56
EXP+	15.46	8.53	75.99
EXPX	9.22	3.32	87.45
EXPXS	14.58	7.16	78.25

2.3 DYNAMIC PROGRAMMING APPROACH TO OPTIMAL BUDGET ALLOCATION

Throughout the discussion in this paper focus has been directed to optimal allocations of budgets to programs. If an optimal allocation is greatly displaced from a base point allocation then a reallocation of program budgets may "jar" the system. In such cases a gradual readjustment of total budget may be made such that restoration to optimal behavior proceeds along reasonably smooth lines. Reference (3) addresses this question for the case of the multiplicative exponential model.

2.4 INPUT REQUIREMENTS

The input requirement for the budget vary according to the number of programs to be considered in any run of the model. The information is required to define basepoint budget considerations and is discussed below.

Input Data Description

The first two input cards are a descriptive title with a maximum length of 130 characters, 80 on card 1 and 50 on card 2. Both cards are required, even when the title is less than 80 characters in length. The remaining cards depend upon the type and number of budget programs to be considered with a minimum of one and a maximum of five.

The first six columns of each succeeding card is a control parameter that may have any of the following values:

- BUDGET - indicates baseline budget
- ACCESS - indicates baseline accession
- BUDLOW - minimum budget to be considered
- BUDUP - maximum budget to be considered
- BUDINC - budget increments
- blank of program name - these cards are required for entering productivity values for each program under consideration
- END - end of budget definition

In the case of program productivity, two cards are required, identified by the following control words in columns 11 through 16.

PRRATE - productivity rate for budget programs
BUD-$M - basepoint budget for this program is
millions of dollars

A maximum of five program budgets may be entered. The remaining entry on each card is the numerical value corresponding to the identifying control words. These values are in columns 21-30 and two considerations must be considered. First, the decimal point must be in the field and, second, all budgets are expressed in terms of millions of dollars.

Two cards follow the 'END' card of the budget definition series. These cards provide data concerning demand limited supply groups under the following formats.

Card	Columns	Format	Definition
1	1-10	A10	Service name (ARMY, NAVY, USAF, USMC)
	11-20	F10.1	Maximum number of female enlistments
	21-30	F10.1	Maximum number prior service enlistments
	31-35	F10.5	Expected proportion GED enlistments
	36-40	F10.5	Expected proportion HSG enlistments
	41-50	F10.5	Expected proportion MC IV enlistments
2	1-10	A10	Service name
	11-20	F10.1	Maximum number of MC IV HSG enlistments
	21-30	F10.1	Maximum number of NHSG enlistments
	31-40	F10.1	Total accessions objective

If the demand-limited reports are not desired the service name on each card must be replaced with the keyword NO in columns 1-2.

3 RECRUITER ALLOCATION MODEL

3.1 INTRODUCTION

This chapter describes the methodology developed for determining the optimal allocation of recruiters and/or canvassers throughout the United States, and the resultant allocations by DRC. In addition, a complete description of input data requirements is provided along with operational considerations.

The model optimally allocates recruiters and recruiter assistants to stations distributed across the United States. Specifically, several classes of supply-limited groups of first-term enlistees are defined, e.g., high school graduates, Mental Category I-IIIA. These supply-limited classes then become the focus for the minimal cost allocation of recruiters and recruiter assistants under a broad range of objectives which include national goals, regional goals, combat arms goals, and term-of-service goals.

Model input parameters which are evaluated using cross-sectional analyses include unemployment rates, regional attitudes toward the military, historical propensities to enlist, advertising, and other influencing factors. The parameter elasticities of the recruiters and recruiter assistants for specific types of supply-limited groups are also evaluated.

A full range of optimal solutions is produced by the model, which enables the user to interact and ask questions about the effects of factors such as future unemployment rates on planning. Sensitivity analysis is also available, again pointing out the effects of special requirements on total minimal cost.

A system overview of the general characteristics of the inputs and outputs to the model is illustrated in Figure 3.1. A more detailed discussion of these elements will be presented later in this chapter.

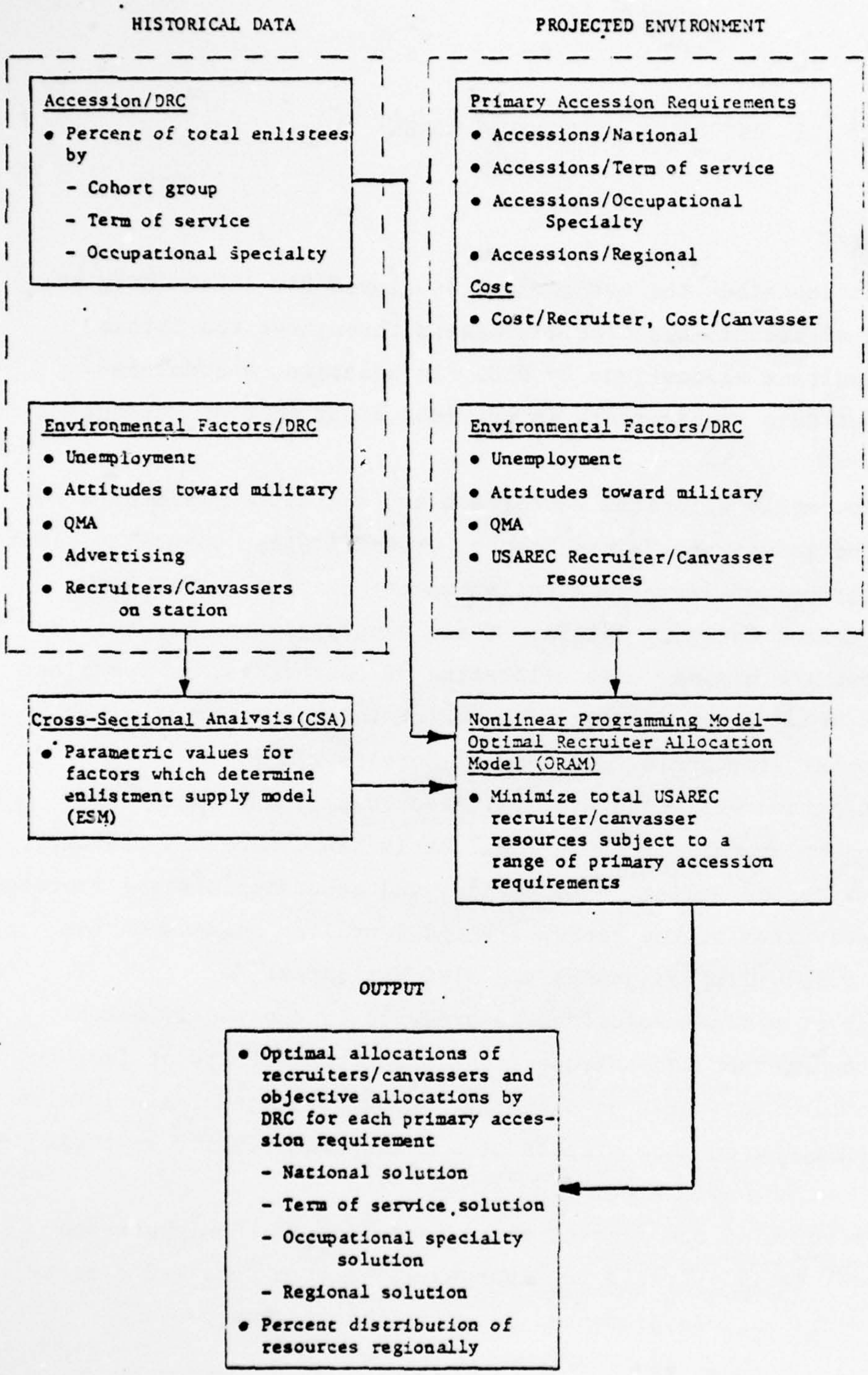

Fig. 3.1—ORAM System Overview

3.2 THE OPTIMAL RECRUITER ALLOCATION MODEL (ORAM) METHODOLOGY

This section contains a precise formulation of the mathematical optimization problems which are solved by the computer algorithm. A statement of the problem is first presented, followed by the Lagrangian formulation of the equivalent problems. The Lagrangian stationary conditions are then derived.

Five optimization problems (denoted by the index p; p = 1,...,5) will now be formulated. The notational conventions used in this discussion are as follows:

Notation

The following notation will be used for the optimization problems.

Problem size

• Number of DRCs	N	$N \leq 64$
• Number of regions	M	$M = 5$ (currently)
• Number of different supply limited cohort types	J	$J \leq 8$
• Number of choices of term of service	K	$K = 2$
• Number of choices of occupational specialty	L	$L \leq 2$
• Number of independent variables	N	If recruiters are only independent variables
	2N	If recruiters and canvassers are independent variables
• Number of dependent variables	NJ	$NJ \leq 512$

Independent variables

X_i : the number of recruiters on station, district i (i=1,...,N)

Y_i : the number of canvassers on station, district i (i=1,...,N)

X^*_{ip} : the optimal value of X_i when solving problem p

Y^*_{ip} : The optimal value of Y_i when solving problem p

Historical percentages or fractions

$t_{ijk\ell}$: the fraction of total enlistees within district i of cohort type j with term of service k and occupational specialty ℓ

$(i=1,\ldots,N)$, $(j=1,\ldots,8)$, $(k=1,2)$, $(\ell=1,2)$

where

k=1 : 3 year term of service

2 : 4+ year term of service

ℓ=1 : combat arms

2 : non-combat arms

$t'_{ijk\ell}$: $t'_{ijk\ell} = \dfrac{t_{ijk\ell}}{\sum_{j=1}^{J} t_{ijk\ell}}$ Note: $\sum_{jk\ell} t_{ijk\ell} = 1$

Costs

γ : annual cost of placing an additional recruiter in a district

δ : annual cost of placing an additional canvasser in a district

Upper limits

$\bar{Y}$: upper limit of total number of canvassers

Primary accession requirements

T_s : total accessions across supply limited cohort types j, $(j=1,\ldots,J)$

T_s is accession requirement for optimization problem 1 $(p=1)$

S_k : term of service requirements across supply limited cohort types j, $(j=1,\ldots,J)$

k=1,2 corresponds to optimization problems 2 and 3 $(p=2,3)$

O_ℓ : occupational specialty requirement across supply limited cohort types j, (j=1,...,J)
ℓ=1 corresponds to optimization problem 4 (p=4)

$\varphi_m T_s$: total accessions across supply limited cohort types j, (j=1,...,J) in region indexed by m, (m=1,...,M) where φ_m is the fraction of T_s which is required to be in region m.

Note: generally $\sum_m \varphi_m = 1$

The set of regional requirements corresponds to optimization problem 5 (p=5)

Dependent variables*

E_{ij} : number of accessions of cohort type j enlisting in district i

$$E_{ij} = Q_{ij}^{\alpha_{1j}} W_{ij}^{\alpha_{2j}} U_{ij}^{\alpha_{3j}} G_{ij}^{\alpha_{4j}} A_{ij}^{\alpha_{5j}} (X_i^{\alpha_{6j}} + Y_i^{\alpha_{7j}}) V_j$$

Statement of the five optimization problems

Problem 1

$$\min_{X_i, Y_i} \sum_{i=1}^{N} (\gamma X_i + \delta Y_i) \qquad \text{(cost)}$$

*The terms Q_{ij}, U_{ij}, G_{ij}, A_{ij}, V_j are defined in Chapter 5, Analysis for Management of Recruiting Resources and Operations, Paul S. Souder, Jr., et al, OAD-CR-166.

subject to

$$\sum_{\substack{i=1 \\ j=1}}^{N,J} Q_{ij}^{\alpha_{1j}} W_{ij}^{\alpha_{2j}} U_{ij}^{\alpha_{3j}} G_{ij}^{\alpha_{4j}} A_{ij}^{\alpha_{5j}} \left(X_i^{\alpha_{6j}} + Y_i^{\alpha_{7j}} \right) V_j = T_S$$

(total accession requirement)

$$\sum_{i=1}^{N} Y_i \leq \overline{Y} \qquad \text{(upper limit on canvassers)}$$

Problems 2, 3

$$\min_{X_i, Y_i} \sum_{i=1}^{N} (\gamma X_i + \delta Y_i) \qquad \text{(cost)}$$

subject to

$$\sum_{\substack{i=1 \\ j=1}}^{N,J} \left(\sum_{\ell=1}^{2} t'_{ijk\ell} \right) Q_{ij}^{\alpha_{1j}} W_{ij}^{\alpha_{2j}} U_{ij}^{\alpha_{3j}} G_{ij}^{\alpha_{4j}} A_{ij}^{\alpha_{5j}} \left(X_i^{\alpha_{6j}} + Y_i^{\alpha_{7j}} \right) V_j = S_k$$

(term of service requirements, k = 1,2)

$$\sum_{i=1}^{N} Y_i \leq \overline{Y} \qquad \text{(upper limit on canvassers)}$$

where k = 1 corresponds to three-year term of service requirement (problem 2) and k = 2 corresponds to four-or-more-year term of service requirement (problem 3)

Problem 4

$$\min_{X_i, Y_i} \sum_{i=1}^{N} (\gamma X_i + \delta Y_i) \qquad \text{(cost)}$$

subject to

$$\sum_{\substack{i=1 \\ j=1}}^{N,J} \left(\sum_{k=1}^{k} t_{ijk\ell} \right) Q_{ij}^{\alpha_{1j}} W_{ij}^{\alpha_{2j}} U_{ij}^{\alpha_{3j}} G_{ij}^{\alpha_{4j}} A_{ij}^{\alpha_{5j}} \left(X_i^{\alpha_{6j}} + Y_i^{\alpha_{7j}} \right) V_j = O_\ell$$

(occupational specialty requirement)

$$\sum_{i=1}^{N} Y_i \leq \overline{Y} \qquad \text{(upper limit on canvassers)}$$

where $\ell = 1$ corresponds to combat arms

<u>Problem 5</u>

$$\min_{X_i, Y_i} \quad \sum_{i=1}^{N} (\gamma X_i + \delta Y_i) \qquad \text{(cost)}$$

subject to

$$\sum_{\substack{i=1 \\ j=1}}^{N,J} Q_{ij}^{\alpha_{1j}} W_{ij}^{\alpha_{2j}} U_{ij}^{\alpha_{3j}} G_{ij}^{\alpha_{4j}} A_{ij}^{\alpha_{5j}} \left(X_i^{\alpha_{6j}} + Y_i^{\alpha_{7j}} \right) V_j = \varphi_m T_S$$

$$(m=1,\ldots,M)$$

(regional accession requirements)

$$\sum_{i \in I_m} Y_i \leq \varphi_m \overline{Y} \qquad (m=1,\ldots,M)$$

(regional upper limits on canvassers)

where $I_m = \{ i \mid \text{district } i \text{ is in region } m \}$

The Lagrangian Formulation of the Optimization Problems

Several notational simplifications will be made before proceeding to the Lagrangian formulations of the five optimization problems. The simplifications are as follows:

$$C_{ij} = Q_{ij}^{\alpha_{1j}} W_{ij}^{\alpha_{2j}} V_{ij}^{\alpha_{3j}} G_{ij}^{\alpha_{4j}} A_{ij}^{\alpha_{5j}} V_j$$

$$b_j = \alpha_{6j}$$

$$d_j = \alpha_{7j}$$

$$h_{ijp} = \begin{cases} C_{ij} & \text{if } p = 1 \\ \left(\sum_{\ell=1}^{2} t'_{ij1\ell}\right) C_{ij} & \text{if } p = 2 \\ \left(\sum_{\ell=1}^{2} t'_{ij2\ell}\right) C_{ij} & \text{if } p = 3 \\ \left(\sum_{k-1}^{2} t_{ijk1}\right) C_{ij} & \text{if } p = 4 \\ C_{ij} & \text{if } p = 5 \end{cases}$$

The five optimization problems now are rewritten using the concise notation.

Problem p, (p=1,...,4)

$$\min_{X_i, Y_i} \sum_{i=1}^{N} (\gamma X_i + \delta Y_i) \quad \text{(cost)}$$

$$\text{subject to} \sum_{i=1}^{N} \sum_{j=1}^{J} h_{ijp} \left(X_i^{b_j} + Y_i^{d_j} \right) = \begin{cases} T_S = R_1 & \text{if } p = 1 \\ S_1 = R_2 & \text{if } p = 2 \\ S_2 = R_3 & \text{if } p = 3 \\ O_1 = R_4 & \text{if } p = 4 \end{cases}$$

(primary requirement constraint)

$$\sum_{i=1}^{N} Y_i \leq \overline{Y}$$

(canvasser constraint)

Problem 5 (p=5)

$$\min_{X_i, Y_i} \sum_{i=1}^{N} (\gamma Y_i + \delta Y_i)$$

subject to:

$$\sum_{i \in I_m} \sum_{j=1}^{J} h_{ijp} \; X_i^{b_j} + Y_i^{d_j} = \varphi_m T_S \quad (m=1,\ldots,M)$$

(primary requirement constraints)

$$\sum_{i \in I_m} Y_i \leq \varphi_m \overline{Y}$$

(canvasser constraints)

Lagrange Multipliers

Lagrange multipliers corresponding to the constraints of problem p (p=1,...,5) are denoted as follows:

For p=1,...,4

λ_p : the Lagrange multiplier corresponding to the primary requirements constraint of problem p, (p=1,...,4) $\lambda_p \geq 0$

μ_p : the Lagrange multiplier corresponding to the canvasser constraint of problem p, (p=1,...,4) $\mu_p \geq 0$

For p=5

$\overline{\lambda}_m$: the Lagrange multiplier corresponding to the five regional accession requirements of problem 5. $\overline{\lambda}_m \geq 0$ (m=1,...,M)

$\overline{\mu}_m$: the Lagrange multiplier corresponding to the five regional canvasser requirements of problem 5. $\overline{\mu}_m \geq 0$ (m=1,...,M).

Lagrangian Functions

Five Lagrangian functions are now formulated.*

For problems (p=1,...,4) the Lagrangian function is defined by the equation:

$$\mathcal{L}_p\left(X,Y;\lambda_p,\mu_p\right)=\begin{cases}\sum_{i=1}^{N}(\gamma X_i+\delta Y_i)-\lambda_p\left(\sum_{\substack{i=1\\j=1}}^{N,J} h_{ijp}\,(X_i^{b_j}+Y_i^{d_j})-R_p\right)\\[2ex] -\mu_p\left(\overline{Y}-\sum_{i=1}^{N}Y_i\right)\end{cases}$$

For problem 5 (p=5) the Lagrangian function is defined by the equation

$$\mathcal{L}_p\left(X,Y;\overline{\lambda}_m,\overline{\mu}_m\right)=\begin{cases}\sum_{i=1}^{N}(\gamma X_i+\delta Y_i)-\sum_{m=1}^{M}\overline{\lambda}_m\left(\sum_{\substack{i\in I_m\\j=1}}^{J} h_{ijp}\left(X_i^{b_j}+Y_i^{d_j}\right)-\varphi_m T_s\right)\\[2ex] -\sum\overline{\mu}_m\left(\varphi_m\overline{Y}-\sum_{i\in I_m}Y_i\right)\,.\end{cases}$$

The Kuhn-Tucker Conditions for the ORAM

The five Lagrangian functions $\mathcal{L}_p$, (p=1,...,5) are convex in X_i, Y_i provided $0 < b_j \leq 1$, $0 < d_j \leq 1$, (j=1,...,J). Thus the Kuhn-Tucker necessary conditions are also sufficient for an optimal solution.

The Kuhn-Tucker conditions that are satisfied by optimal solutions X^*_{ip}, Y^*_{ip}, solved by the ORAM are for p=1,...,4 as follows:

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*The following references are fundamental to the study presented here:

- Kuhn, H.W., and Tucker, A.W., "Nonlinear Programming," Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability." University of California Press, Berkeley, 1951.
- McCormick, G.P., "Second Order Conditions for Constrained Minima," SIAM Journal Applied Math. 15 (3), pp. 641-652, 1967.
- Fiacco, A.V., and McCormick, G.P., Nonlinear Programming, Sequential Unconstrained Minimization Techniques, New York, John Wiley and Sons, Inc., 1968.

$$\frac{\partial \mathcal{L}_p}{X^*_{ip}} = 0, \quad \frac{\partial \mathcal{L}_p}{Y^*_{ip}} = 0 \quad (i=1,\ldots,N)$$

$$\frac{\partial \mathcal{L}_p}{\lambda^*_p} = 0, \quad \frac{\partial \mathcal{L}_p}{\mu^*_p} \le 0 \qquad (p=1,\ldots,4)$$

$$\mu^*_p \left(\overline{Y} - \sum_{i=1}^{N} Y^*_{ip}\right) = 0$$

$$X^*_{ip} \ge 0, \; Y^*_{ip} \ge 0 \quad (i=1,\ldots,N)$$

$$\lambda^*_p \ge 0, \; \mu^*_p \ge 0$$

where λ^*_p, μ^*_p are the values of the Lagrange multipliers at the optimizing point X^*_{ip}, Y^*_{ip}.

For problem 5 (p=5) the Kuhn-Tucker conditions are

$$\frac{\partial \mathcal{L}_p}{\partial X^*_{ip}} = 0, \quad \frac{\partial \mathcal{L}_p}{\partial Y^*_{ip}} = 0 \qquad (i=1,\ldots,N)$$

$$\frac{\partial \mathcal{L}_p}{\partial \overline{\lambda}^*_m} = 0, \quad \frac{\partial \mathcal{L}_p}{\partial \overline{\mu}^*_m} \le 0 \qquad (m=1,\ldots,M)$$

$$\overline{\mu}^*_m \left(\varphi_m \overline{Y} - \sum_{i \in I_m} Y^*_{ip}\right) = 0 \qquad (m=1,\ldots,M)$$

$$X^*_{ip} \ge 0, \quad Y^*_{ip} \ge 0$$

$$\overline{\lambda}^*_m \ge 0, \quad \overline{\mu}^*_m \ge 0 \qquad (m=1,\ldots,M)$$

where $\overline{\lambda}^*_m$, $\overline{\mu}^*_m$ (m=1,...,M) are the values of the Lagrange multipliers at the optimizing point X^*_{ip}, Y^*_{ip}. Points satisfying the Kuhn-Tucker conditions are called Kuhn-Tucker points.

A Procedure for Solving for Kuhn-Tucker Points

This section is very detailed and describes the algorithm which is used to solve the optimization problems by means of a process which converges to the Kuhn-Tucker points just described. The algorithm seeks solutions to the following set of equations and inequalities:

For problems p, (p=1,...,4)

$$\sum_{j=1}^{J} b_j h_{ijp} X_i^{b_j - 1} = \frac{\gamma}{\lambda_p}, \quad \sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = \frac{\delta + \mu_p}{\lambda_p} \qquad (i=1,\ldots,N)$$

$$\sum_{i=1}^{N} \sum_{j=1}^{J} h_{ijp} \left(X_i^{b_j} + Y_i^{d_j} \right) = R_p, \quad \overline{Y} - \sum_{i=1} Y_i \geq 0$$

$$\mu_p \left(\overline{Y} - \sum_{i=1}^{N} Y_i \right) = 0$$

$$X_i \geq 0,\ Y_i \geq 0,\ \lambda_p \geq 0,\ \mu_p \geq 0 \qquad (i=1,\ldots,N).$$

For problem 5, (p=5) the following set of equations and inequalities is solved.

$$\sum_{j=1}^{J} b_j h_{ijp} X_i^{b_j - 1} = \frac{\gamma}{\lambda_m}, \quad \sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = \frac{\delta + \overline{\mu}_m}{\overline{\lambda}_m}$$

$$\sum_{i \in I_m} \sum_{j=1}^{J} h_{ijp} X_i^{b_j} = \varphi_m T_S, \quad \varphi_m \overline{Y} - \sum_{i \in I_m} Y_i \geq 0$$

$$\overline{\mu}_m \left(\varphi_m \overline{Y} - \sum_{i \in I_m} Y_i \right) = 0$$

$$X_i \geq 0,\ Y_i \geq 0,\ \overline{\lambda}_m \geq 0,\ \overline{\mu}_m \geq 0$$

where $i \in I_m$, $(m=1,\ldots,M)$.

- A three part decision rule is used to solve for Kuhn-Tucker points. Each part is called a branch and uses a Fibonacci search technique to determine the solutions to its particular set of equations. A Newton method is used to solve equations (1a), (2a) (3a) (following) within branches 1, 2, 3 as functions of the right side values. The Fibonacci search is made to satisfy equations (1b), (2b), and (3b).

The decision branch rules for problem p, (p=1,...,4) will now be discussed.

<u>Decision Branch Rules</u> (problem p, p=1,...,4)

- <u>Branch 1.</u> Solve for Y_i (i=1,...,N) and v the (N+1) equations

$$\text{(1a)} \quad \sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = v \quad (i=1,\ldots,N)$$

where v is a candidate value for $\frac{\delta+\mu_p}{\lambda_p}$

such that

$$\text{(1b)} \quad \sum_{i=1}^{N} Y_i = \overline{Y}$$

$$\text{If} \begin{cases} \sum_{i=1}^{N} \sum_{j=1}^{J} h_{ijp} Y_i^{d_j} = Z \le R_p & \text{then retain the value v and go to branch 2} \\ \sum_{i=1}^{N} \sum_{j=1}^{J} h_{ijp} Y_i^{d_j} = Z > R_p & \text{go to branch 3} \end{cases}$$

- <u>Branch 2.</u> Solve for X_i (i=1,...,N) and w the (N+1) equations

$$\text{(2a)} \quad \sum_{j=1}^{J} b_j h_{ijp} X_i^{b_j - 1} = w$$ where w is a candidate value for $\frac{\gamma}{\lambda_p}$

such that

$$\text{(2b)} \quad \sum_{i=1}^{N} \sum_{j=1}^{J} h_{ijp} X_i^{b_j} = R_p - Z$$

From the relations $v = \dfrac{\delta + \mu_p}{\lambda_p}$, $w = \dfrac{\gamma}{\lambda_p}$

evaluate $\mu_p = \dfrac{v\gamma}{w} - \delta$

If $\mu_p \geq 0$ then X_i, $Y_i (i=1,\ldots,N)$ and λ_p, μ_p satisfy the Kuhn-Tucker conditions and thus $X^*_{ip} = X_i, Y^*_{ip} = Y_i, \lambda^*_p = \lambda_p, \mu^*_p = \mu_p$ $(i=1,\ldots,N)$ and problem p is solved. If $\mu_p < 0$ go to branch 3.

- Branch 3. Solve for X_i, Y_i $(i=1,\ldots,N)$, λ_p, the (2N+1) equations

(3a) $$\sum_{j=1}^{J} b_j h_{ijp} X_i^{b_j - 1} = \frac{\gamma}{\lambda_p} \; ; \; \sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = \frac{\delta}{\lambda_p} \quad (i=1,\ldots,N)$$

(3b) such that

$$\sum_{i=1}^{N} \sum_{j=1}^{J} h_{ijp} \left(X_i^{b_j} + Y_i^{d_j} \right) = R_p$$

Brief Discussion of Branches

Branch 1 considers the contribution of the total number of canvassers $\overline{Y}$ to the primary accession requirement R_p. If the number of accessions Z attained by $\overline{Y}$ canvassers exceeds the primary requirement R_p then clearly the total number of canvassers is too large and a smaller number will be calculated in branch 3. If, however, the accessions attained by canvassers is less than the total requirement then the associated values for recruiters will be calculated in branch 2 with the accession requirement now being the value $(R_p - Z.)$

Branch 2 completes the candidate solutions for recruiters X_i and canvassers Y_i and then tests the value of the Lagrange multiplier μ_p for non-negativity. If μ_p is negative the cost of the $\overline{Y}$ canvassers is too large for the accessions attained and branch 3 then calculates the appropriate new value of total canvassers. Notice that the Kuhn-Tucker conditions

$$\mu_p \left(\overline{Y} - \sum_{i=1}^{N} Y_i \right) = 0, \; \mu_p \geq 0$$

are tested by branch 2.

Branch 3 is used if there are no canvassers in the model or if there are canvassers and they either cost too much or are not all required because they are able to exceed the accession requirements.

Decision Branch Rules Problem 5

For problem 5 the branch rules are applied to each region m (m=1,...,5) separately. The rules are the same. The following modifications in notation should be made. Primed relations denote changes to corresponding unprimed relations of the preceding section.

For (m=1,...,M), p = 5

- Branch 1'. Solve for Y_i, $i \in I_m$ and $\overline{v}_m$ the equations

$$(1a)' \quad \sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = \overline{v}_m$$

such that

$$(1b)' \quad \sum_{i \in I_m} Y_i = \varphi_m \overline{Y}$$

If
$$\sum_{i \in I_m} \sum_{j=1}^{J} h_{ijp} Y_i^{d_j} = \overline{Z}_m \leq \varphi_m T_S$$ then retain the value $\overline{v}_m$ and go to branch 2'

$$\sum_{i \in I_m} \sum_{j=1}^{J} h_{ijp} Y_i^{d_j} = \overline{Z}_m > \varphi_m T_S$$ go to branch 3'

- Branch 2'. Solve for X_i, $i \in I_m$ and $\overline{W}_m$ the equations

$$(2a)' \quad \sum_{j=1}^{T} b_j h_{ijp} X_i^{b_j - 1} = \overline{W}_m$$ where W is a candidate value for $\frac{\gamma}{\overline{\lambda}_m}$

such that

$$(2b)' \quad \sum_{i \in I_m} h_{ijp} X_i^{b_j} = \varphi_m T_S - \overline{Z}_m$$

From the relations $\bar{v}_m = \dfrac{\delta + \mu_m}{\bar{\lambda}_m}$, $\bar{W}_m = \dfrac{\gamma}{\bar{\lambda}_m}$

evaluate $\bar{\mu}_m = \dfrac{\bar{v}_m \gamma}{\bar{W}_m} - \delta$

If $\bar{\mu}_m \geq 0$ then X_i, Y_i $i \in I_m$ and $\bar{\lambda}_m$, $\bar{\mu}_m$ satisfy the Kuhn-Tucker conditions and thus $X^*_{ip} = X_i$, $Y^*_{ip} = Y_i$, $\bar{\lambda}^*_m = \bar{\lambda}_m$, $\bar{\mu}^*_m = \bar{\mu}_m$ $i \in I_m$.

If $\bar{\mu}_m < 0$ go to branch 3′

- Branch 3′. Solve for X_i, Y_i $i \in I_m$, $\bar{\lambda}_m$, the equations

$$(3a)' \quad \sum_{j=1}^{J} b_j h_{ijp} X_i^{b_j - 1} = \frac{\gamma}{\bar{\lambda}_p} \; ; \quad \sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = \frac{\delta}{\bar{\lambda}_p}$$

$$i \in I_m$$

such that

$$(3b)' \quad \sum_{i \in I_m} \sum_{j=1}^{J} h_{ijp} \left(X_i^{b_j} + Y_i^{d_j} \right) = \varphi_m T_S$$

The Fibonacci Search and Newton Iteration

All "b" branch conditions; namely (1b), 2b), (3b), (1b)′, (2b)′, (3b)′, of the decision branch rules for problem p, (p=1,...,5) are solved indirectly by means of finding the proper value of the right side values of the "a" branch conditions; namely (1a), (2a), (3a), (1a)′, (2a)′, (3a)′. The right side of the appropriate "a" branch condition is a variable for the Fibonacci Search. Within any given search the associated solutions in terms of the independent variables as functions of the right side are solved by a Newton method.

A detailed examination of the Fibonacci/Newton iteration algorithm as applied to problem p, (p=1,...,4) in branch 1 follows. The iteration is similar for all problems and branches hence no further examination of additional problems and branches is needed to understand the general process.

The problem solved by Fibonacci Search is

$$\min_{L < v < U} \left(\left| \sum_{i=1}^{N} Y_i - \overline{Y} \right| = f(v) \right)$$

subject to the N equations

$$\sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = v \quad (i=1,\ldots,N)$$

where L and U are the lower and upper values of the interval over which the search is made.

Next, denote the optimizing value of v by v^*, the Fibonacci Search iteration index by k and the Newton iteration index by ℓ. The Fibonacci search at iteration k produces an interval (U^k, L^k) such that $L^k < v^* < U^k$ where $U^k - L^k \approx .618033983^k\,(U-L)$. This means, for example, that if the initial interval were 100 units in length, that after 24 iterations the length of the interval containing v^* would be less than .001 units in length. This means v^* is known within an accuracy of .001 units after 24 iterations. Corresponding to each Fibonacci iteration k is a set of N complete Newton iterations. The Newton iterations will be discussed after the Fibonacci process, although they actually occur within the Fibonacci iterations.

The Fibonacci Search Technique

0. $L^o = L$, $U^o = U$, $C_2 = (\sqrt{5}-1)/2$ $C_1 = 1 - C_2$

1. $v_1^{k+1} = C_1\left(U^k - L^k\right)$, $v_2^{k+1} = C_2\left(U^k - L^k\right)$

2. Compare $f\left(v_1^k\right)$ and $f\left(v_2^k\right)$ using the Newton method to evaluate the necessary function values (usually only one of the pair)

3. If $f\left(v_1^k\right) < f\left(v_2^k\right)$

   then $L^{k+1} = L^k$, $U^{k+1} = v_2^k$, $v_1^{k+1} = C_1\left(U^{k+1} - U^{k+1}\right)$, $v_2^{k+1} = v_1^k$

   Go to 2.

4. If $f\left(v_1^k\right) > f\left(v_1^k\right)$

   then $L^{k+1} = v_1^k$, $U^{k+1} = U^k$, $v_1^{k+1} = v_2^k$, $v_2^{k+1} = C_2\left(U^{k+1} - L^{k+1}\right)$

   Go to 2.

5. If $f\left(v_1^k\right) = f\left(v_2^k\right)$

   then if $|v_1^k - v_2^k|$ is sufficiently small

   approximate v^* by $\left(v_1^k + v_2^k\right)/2$ and $f(v^*) \approx 0$ and the process is finished. If $|v_1^k - v_2^k|$ is not sufficiently small then

   $L^k = v_1^k$, $U^k = v_2^k$

   Go to 1.

The Newton Iterations Within the Fibonacci Iteration k

Corresponding to each value v^k (dropping the subscript on v^k) of the Fibonacci process is a set of nonlinear equations which is solved using a Newton method. The Newton method determines the value of $f(v^k)$ in conjunction with the solution to N equations. The Newton method is used in step 2 of the Fibonacci Search to evaluate either $f(v_1^k)$ or $f(v_2^k)$. The Newton method solves the following system of N nonlinear equations:

$$\sum_{j=1}^{J} d_j h_{ijp} Y_i^{d_j - 1} = v^k \quad (i=1,\ldots,N).$$

For each equation i the following iteration on ℓ, the Newton iteration index, is performed.

$$Y_i^{(\ell+1)} = Y_i^{(\ell)} - \frac{\sum_{j=1}^{J} d_j h_{ijp} \; Y_i^{(\ell)\, d_j - 1} - v^k}{\sum_{j=1}^{J} d_j (d_j - 1) \; h_{ijp} \; Y_i^{(\ell)\, d_j - 2}}$$

$$(i=1,\ldots,N)$$

The Newton iteration process stops when $| Y_i^{(\ell+1)} - Y_i^{(\ell)} |$ is sufficiently small. The value of $f(v^k)$ at this point is

$$f(v^k) = | \sum_{i=1}^{N} Y_i^{(\ell+1)} - \overline{Y} |.$$

Control is returned to step 1 of the Fibonacci Search.

Figures 3.2, 3.3, and 3.4 represent graphically the interplay between the Fibonacci Search and the Newton iterations.

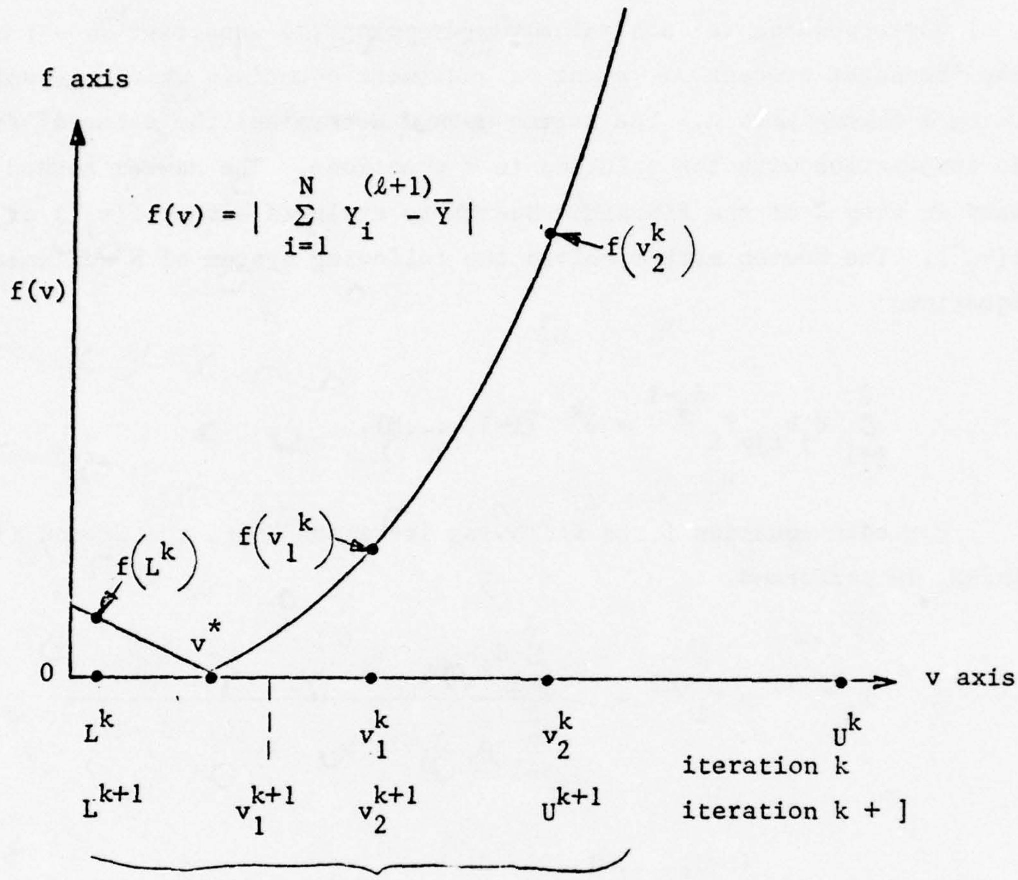

Fig. 3.2—Fibonacci Search

Figure 3.2 depicts the decreasing interval length when passing from iteration k to k+1. Figure 3.3 corresponds to step 3 of the Fibonacci Search technique. It should be noted that $f\left(v_2^{k+1}\right) = f\left(v_1^{k}\right)$ so that only one value, namely $f\left(v_1^{k+1}\right)$ need be calculated for the iteration k+1. The new interval $\left(L^{k+1}, U^{k+1}\right)$ is approximately .618 times the length of the interval $\left(L^k, U^k\right)$. The value $f\left(v_1^{k+1}\right)$ is obtained by using a Newton iteration.

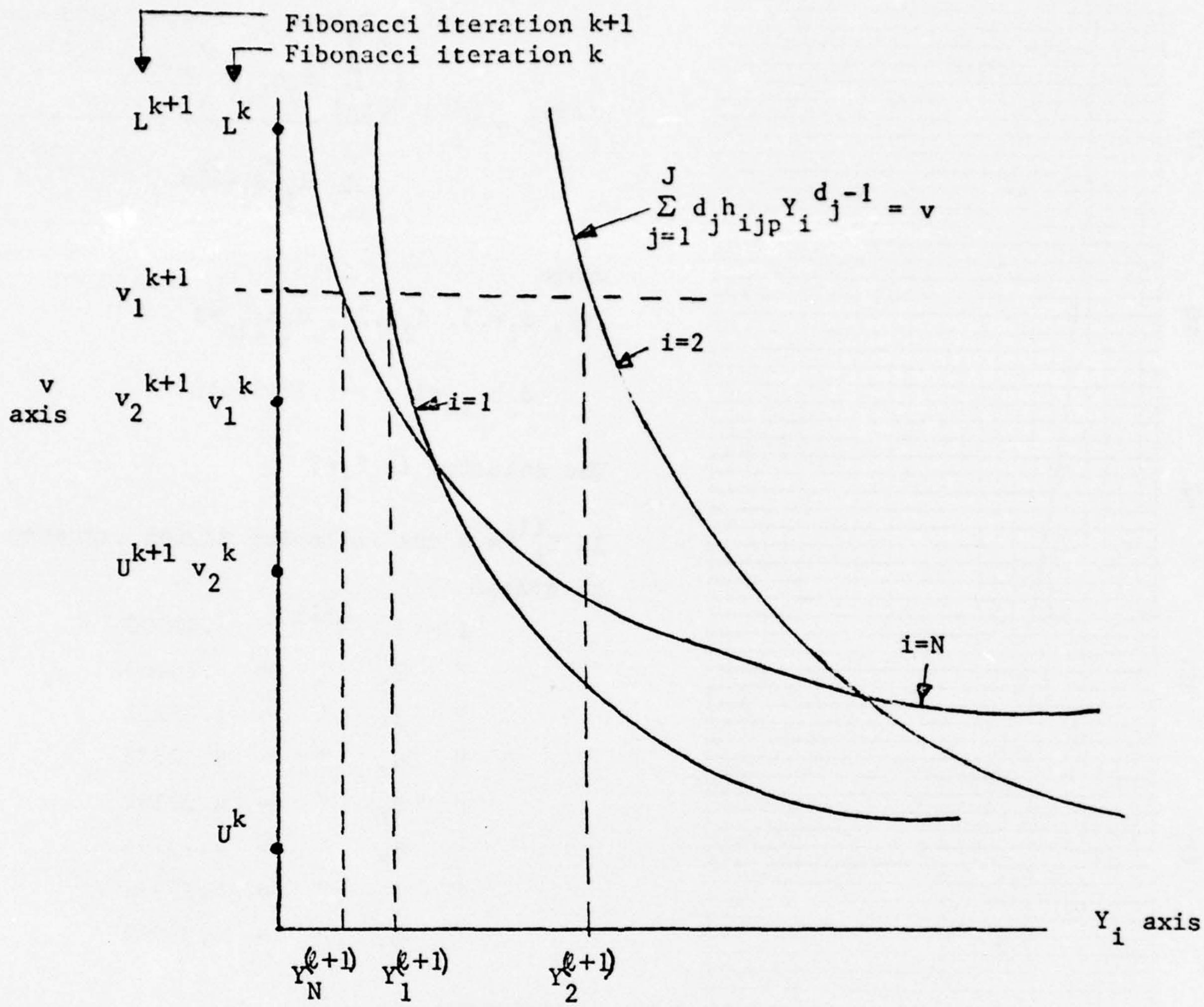

Fig. 3-3—Newton Problem

Figure 3-3 depicts the solution $Y_1, Y_2, \ldots, Y_N$ (three curves are shown here for simplicity) as a function of v_1^{k+1}. $f\left(v\right) = \left| \sum_{i=1}^{N} Y_i^{(\ell+1)} - \overline{Y}\right|$. Figure 3-4 illustrates an actual Newton iteration process as applied to a particular curve. A specific numerical example is given to demonstrate the convergence of $Y_i^{(\ell+1)}$ to the solution point.

Illustration of a Newton iteration sequence

$$Y_i^{(\ell+1)} = Y_i^{(\ell)} - \frac{\left(\sum_{j=1}^{J} d_j h_{ijp}\left(Y_i^{(\ell)}\right)^{d_j-1} - v\right)}{\sum_{j=1}^{J} d_j\left(d_j-1\right)h_{ijp}\left(Y_i^{(\ell)}\right)^{d_j-2}}$$

where

$J=2$, $d_1=.5$, $d_2=.25$, $d_1h_{i1p}=2$

$d_2h_{i2p}=3$ $v=1.79163640$

The solution is $Y_i=5$

If $Y_i^{(1)}=.4$ the following Newton sequence is generated

ℓ =	1,	$Y_i^{(\ell)}$	=	.40000
"	2,	"	=	.88460
"	3,	"	=	1.79272
"	4,	"	=	3.12838
"	5,	"	=	4.39149
"	6,	"	=	4.93794
"	7,	"	=	4.99936
"	8,	"	=	4.99999

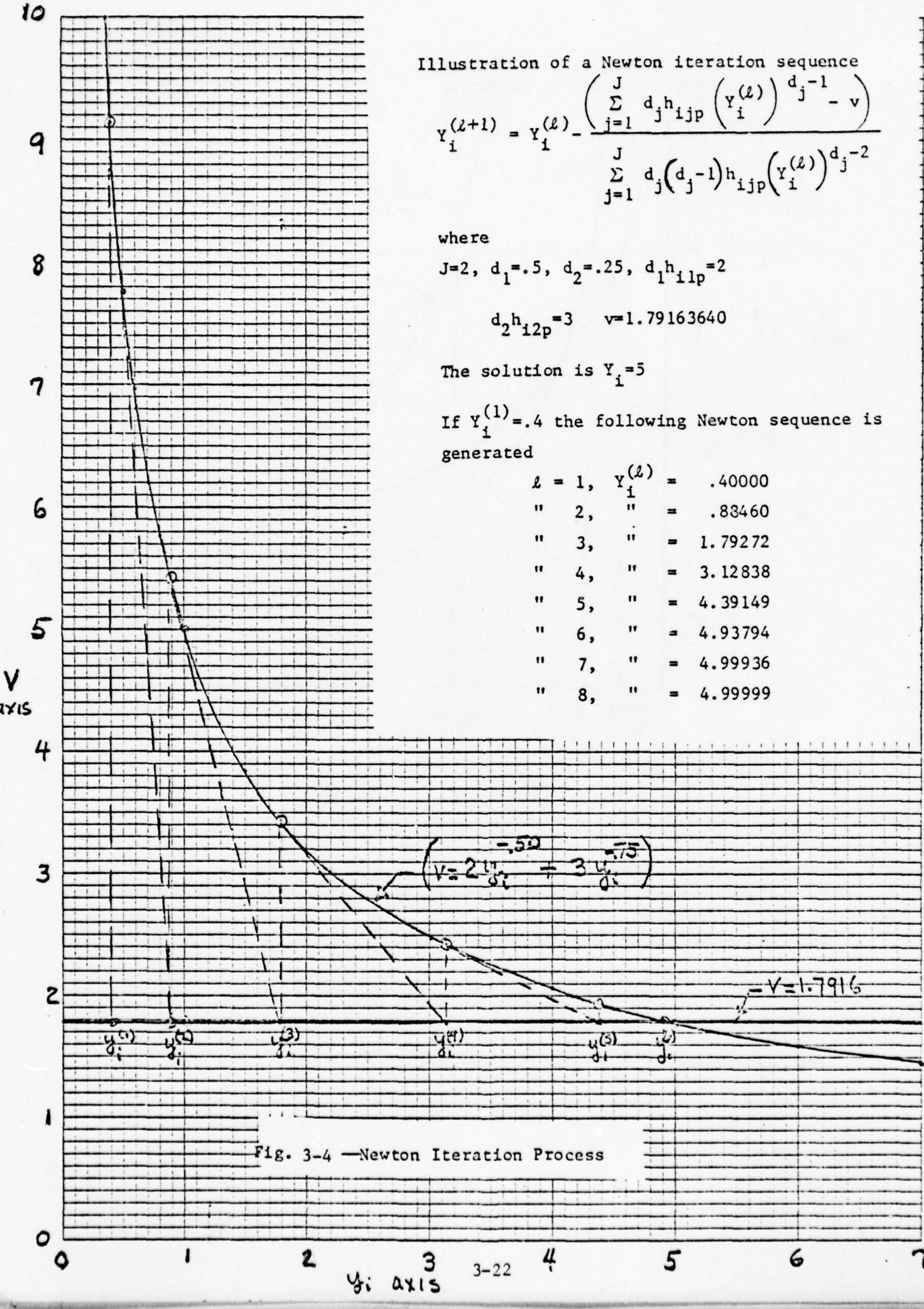

Fig. 3-4 —Newton Iteration Process

3.3 ORAM OPERATIONAL DOCUMENTATION

3.3.1 General Input Data

As the input routine for the ORAM model is currently specified, the first 11 data cards contain general information regarding processing options desired, data adjustment, and boundary conditions. The information required on these cards is detailed below. The user may find it helpful to refer to the annotated listings for the subroutine READIN (App D).

Card	Columns	Entity	Remarks
1-2	1-130	ITITLE	This title appears on all reports.
3	1-5	IRUN	If IRUN = 1, the program will undertake a full optimization. Otherwise, only an evaluation of the initial recruiter/canvasser placement will be performed.
4	1-5	MAXSTA	Number of DRC's to be considered ($\leq$ 65).
	6-10	JTYPES	Number of supply limited types to be considered.
	11-15	KTERMS	Number of different terms of service to be considered.
5	1-5	ISWTCH	If ISWTCH = 1, only recruiters are considered. If ISWTCH = 2, both recruiters and canvassers are considered.
	6-10	ISWPCT	If ISWPCT = 1, a recruiter's marginal productivity with respect to the supply-limited categories is determined by historical accession profiles. Otherwise, the model will accept estimates of these productivities by type. Data indicated by ISWPCT is input as the variable PCTVL.
6	1-10	FUNEMP	FUNEMP is a factor (near 1, e.g., 1.5) which modifies the basic unemployment rates at which the cross-sectional analysis was made.
	11-20	FACTOR	FACTOR adjusts the data for incompleteness: e.g., if data on hand represents 8 months of an annual total, setting FACTOR equal to 1.5 would adjust the incomplete data to an annual value.

Card	Columns	Entity	Remarks
7	1-10	SUPLY	SUPLY is the desired level of supply-limited cohorts.
	11-20	CANTOT	CANTOT is the total canvasser limit.
8	1-10	RECCST	RECCST, CANCST are the relative recruiter and canvasser unit costs. For best convergence properties, set to (e.g.) 1,1 where 1 may actually represent 1 unit of $25,000.
	11-20	CANCST	
9	1-10 11-20	FSERV(1) FSERV(2)	FSERV(K) is the fraction of total supply with term of service type K.
	etc.	etc.	
10	1-10	FCOMBT	FCOMBT is the fraction of total supply in combat arms.
11	1-10	FREGN(1)	FREGN(K) is the fraction of total supply in region K.
	11-20 etc.	FREGN(2) etc.	

3.3.2 DRC Specific Input Data

As the program is currently structured, DRC specific data is input beginning with card number 12. The types of data currently accepted by the program are listed in Table 3.1.

Table 3.1

VARIABLES ACCEPTED FOR ANALYSIS BY ORAM

Identifier	Definitions
QME	Qualified military populations by cohort type
WAGE	Ratio of military to civilian range by cohort type
UNEMP	Unemployment by cohort type
ATT	Attitude measure by cohort type
ADV	Advertising measure (e.g., expenditures) by cohort type
RECR	Recruiters on station by DRC
CANV	Canvassers on station by DRC
PETVL	If ISWPCT = 1, PCTVL is the historical accession file described. If marginal productivities for recruiters by cohort type are to be estimated in some other way, the estimates are input as PCTVL with ISWPCT ≠ 1.

Currently ORAM assigns the same value of QME, WAGE, UNEMP, ATT, ADV, RECR, and CANV to each cohort type. This value is the first and only value input for each DRC. The program is easily modified to allow for input differentiated by cohort type (see annotated program listing for READIN lines 100-175). The general input structure for the variables QME, WAGE, UNEMP, ATT, ADV, RECR and CANV is as follows, where as above MAXSTA is the number of DRC's to be considered.

Card	Columns	Entity	Remarks
1	1-5	IDENTIFIER	Left-justified selection from the following: QME, WAGE, UNEMP, ATT, ADV, RECR, CANV
2 thru	1-5	DRC identifier	
MAXSTA+1	6-7	DRC index	DRCs are assigned consecutive indices beginning with 1.
	8-9	Filler	
	10	Region number	Currently either 1,3,4,5 or 6
	11-18	VAL(1)	Value of the variable for cohort type 1
	19-26	VAL(2)	Value of the variable for cohort type 2
	etc.	etc.	etc.
MAXSTA+2	1-3	'END'	Signifies end of data for the variable under consideration

As noted above, at present VAL(1) is assigned to all cohort types and is accordingly the only value input. A data card must appear for each of the MAXSTA DRCs under consideration. The above format is repeated for each variable to be input.

The marginal productivity for a recruiter by cohort type is currently estimated from the historical accession file described in App C. These data are input under PCTVL as follows.

Card	Columns	Values
First	1-5	'PCTVL'
Following		Historical accession data file
Last	1-3	'END'

(In the event that a direct input of marginal recruiter productivities by cohort type is required, some reprogramming of READIN may be desirable.)

3.3.3 Inputting Model Parameters

For convenience, the following definitions will apply in this section:

X_i: The K independent variables will be denoted X_i for $1 = 1,2,\ldots,K$. E.g., in the sample problem X_1 corresponds to QMA, X_2 to wages, etc.

E(I,J): The elasticity of variable X_I for type J is denoted E(I,J). In the sample problem E(1,J) = E(2,J) = 0 for all J.

CON(J): The value of the scaling constant for the model representing cohort type J is denoted CON(J).

Y(J): The number of accessions arising from cohort type J is denoted Y(J).

In the sample problem and for cohort type J, ORAM considers the following model (described in standard FORTRAN notation):

```
Y(J) = EXP**CON(J)*X(1)**E(1,J)*X(2)**E(2,1)*
       X(3)**E(3,J)*X(4)**E(4,J)*X(5)**E(5,J)
       *X(6)**E(6,J)
```

where

X(1) is QMA,

X(2) is the ratio of military to civilian wages,

X(3) is the general unemployment rate,

X(4) is an advertising measure,

X(5) is an attitude measure

X(6) is recruiters on station,

X(7) is canvassers on station,

CON(J) and E(I,J) are as defined above.

Values for E(I,J) are input as follows:

Card	Columns	Entity	Value	Remarks
1	1-5	Header	'ELAST'	
2	1-5	Identifier		Optional
	6-7	Variable number	I	
	8-11	Filler	Spaces	
	12-19	VAL(1)	E(I,1)	
	20-27	VAL(2)	E(I,2)	
	etc.	etc.	etc.	
3 thru 8	Elasticities for the remaining variables as per format for card 2			
9	1-3	Trailer	'END'	

In its present form READIN expects to be provided with seven sets of elasticities (corresponding to X(1) - X(7)).

Values for CON(J) are input as follows:

Card	Columns	Entity	Value	Remarks
1	1-5	Header	'CONST'	
2	1-5	Identifier		Optional
	6-11	Filler	Space	
	12-19	VAL(1)	CON(1)	
	20-27	VAL(2)	CON(2)	
	etc.	etc.	etc.	
3	1-3	Trailer	'END'	

In the sample problem, constants are provided for each of the eight cohort types considered. For every type, the constant is = .601068; but as noted above, the constants need not be identical.

3.3.4 The Nonlinear Programming Model—Optimal Recruiter Allocation Model (ORAM)

Given all the established input conditions, the ORAM proceeds to solve for the optimal allocation of recruiter/canvassers and objective allocations to each DRC for a set of primary accession requirements. The ORAM, in effect, solves five complete optimization problems per computer run. Specifically, given the input conditions of the model, what is the most cost-effective allocation of recruiters/canvassers if:

1. A total national goal of $\underline{X}$ number of accessions is required?
2. A total national goal of $\underline{X}$ number of accessions with 3-year terms of service is required?
3. A total national goal of $\underline{X}$ number of accessions with 4-year and greater term of service is required?
4. A total national goal of $\underline{X}$ number of accessions with combat arms specialty is required?
5. A regional goal of $\emptyset_m$ percent of the $\underline{X}$ number of total accessions is required in region $m(m=1,...,m)$?

3.3.5 ORAM Model Outputs

The optimal allocation solutions to the ORAM are used as a basis for a series of output report evaluations. Each evaluation is fairly detailed and provides the following information by DRC:

- DRC Identification
- DRC Number
- Number of Recruiters on Station
- Number of Canvassers (where applicable)
- Number of Accessions (total)
- Number of Accessions by Cohort Group

In addition, subtotals by region, totals nationally, percent regional and national summary tables are printed.

All of the above information is evaluated for each of five optimal solutions and for each of five accession content situations within each optimal solution. Figure 3-5, Output Report Guide, depicts the range of evaluations which are made. Each cell represents a particular set of conditions for which a complete evaluation is made. Figure 3-6 presents one of the 25 output reports printed after the five ORAM optimizations are completed. The sample report depicts the combat arms content for CAT123AHSG black and white when the overall strategy is to meet a total national requirement (p=1) of 54568 CAT123AHSG accessions.* Using the notation of Fig. 3-5, the sample report is R_{11}. The values of the parameters determined from the cross section analysis are as follows:

recruiters	$\alpha_{61} = \alpha_{62} = .835798$
unemployment	$\alpha_{31} = \alpha_{32} = .41938$
attitudes	$\alpha_{41} = \alpha_{42} = .724$
constant	$V_1 = V_2 = 1.5 \exp(-.908979) = .604403$

These values of the parameters yield the following accession equation for DRC i:

For black content:

$$\text{CAT123AHSGB}_i = (\%\ \text{black}_i)^{**}\ (.604403)\ (\text{Unemployment}_i)^{.419138} \cdot (\text{Attitudes}_i)^{.72482} \cdot (\text{Recruiters}_i)^{.835798}$$

For white content:

$$\text{CAT123AHSGW}_i = (\%\ \text{white}_i)^{**}\ (.604403)\ (\text{Unemployment}_i)^{.419138} \cdot (\text{Attitudes}_i)^{.72482} \cdot (\text{Recruiters}_i)^{.835798}$$

For any particular DRC the appropriate values of the environmental factors determine the coefficients of the recruiter accession equation. For example, the enlistment supply equation for DRC 1A, Albany, in region one is evaluated as follows for CAT123AHSG black and white.

---

*This is based upon CAT I-IIIA, HSG being the supply limited group. If the mix of the supply-limited group changes, ORAM's coverage must also be changed to encompass all of the supply-limited categories.

**Historical percentage breakout by DRC.

Evaluation of Accession Content(q) → / ↓ Optimal Solution (p)	q=1 National	q=2 3-Yr Term	q=3 4-Yr+ Term	q=4 Combat Arms	q=5 Regional
p=1 National	National Optimal				
p=2 3-Yr Term		3-Yr Term Optimal	R^{*}_{pq}		
p=3 4-Yr+ Term			4-Yr+ Term Optimal		
p=4 Combat Arms				Combat Arms Optimal	
p=5 Regional					Regional Optimal

$^{*}R_{pq}$ is the evaluation report of accession content q based on the optimal allocation of recruiters/canvassers to primary requirement p.

Example: R_{23} is the evaluation report of the number 123AHSG accessions enlisting for four or more years if the recruiters/canvassers are allocated to achieve a specified three-year term of service objective at minimum cost. (See Fig. 3-6 for an example of output report R_{11}.)

Fig. 3-5—Output Report Guide

STRATEGY - MIN COST SUBJECT TO NATIONAL TOTAL ACCESSION REQUIREMENT 54568.
SUPPLY LIMITED TYPES 1 , 2 - CAT123AHSG 161103 TOTAL REQ. WITH 33.8 PERCENT SUPPLY RECR. ELASTICITY = .835 . UNEMPL. = 7.7

DRC	NO.	NO. RECRUITERS	NO. ACCESSIONS	ACCESSIONS BY TYPE TYPE 1	TYPE 2	TYPE
				REGION 1		
1A	1	33.9	418.4	8.0	410.3	
1B	2	16.1	198.7	35.7	163.0	
1C	3	57.4	708.1	21.0	687.1	
1D	4	28.0	345.4	.8	344.7	
1E	5	25.3	312.1	7.3	304.8	
1F	6	31.9	393.1	23.3	369.9	
1G	7	33.9	418.4	98.0	320.4	
1H	8	33.9	418.4	82.1	336.3	
1I	9	38.2	471.8	71.7	403.1	
1J	10	33.9	418.4	19.8	398.5	
1K	11	30.9	380.8	87.9	292.9	
1L	12	23.6	291.0	13.2	277.8	
1M	13	68.0	838.8	20.9	817.8	
1N	14	33.9	418.4	5.0	413.4	
1O	15	11.9	146.3	36.2	110.1	
SUBTOTALS		500.7	6178.1	531.0	5647.1	
				REGION 3		
3A	16	149.2	1840.7	584.1	1256.7	
3B	17	76.4	942.2	102.6	839.6	
3C	18	149.2	1840.7	535.9	1304.9	
3D	19	185.8	2292.3	1183.4	1108.8	
3E	20	169.5	2091.4	325.9	1765.4	
3F	21	90.0	1110.9	85.1	1025.9	
3G	22	180.3	2224.1	486.3	1737.8	
3H	23	109.1	1346.1	555.7	790.4	
3I	24	97.4	1201.7	146.5	1055.2	
3J	25	149.2	1840.7	1074.1	766.6	
3K	26	61.2	754.5	335.4	419.2	
SUBTOTALS		1417.2	17485.4	5415.0	12070.4	
				REGION 4		
4A	27	96.2	1187.0	39.1	1147.8	
4B	28	41.9	517.2	18.7	498.5	
4C	29	41.9	517.2	104.2	413.1	
4D	30	30.7	378.2	11.0	367.3	
4E	31	41.9	517.2	119.2	398.0	
4F	32	65.7	810.4	404.4	406.0	
4G	33	37.9	468.0	24.6	443.3	
4H	34	96.2	1187.0	399.5	787.5	
4I	35	103.2	1273.0	472.2	800.8	
4J	36	41.9	517.2	32.3	485.0	
4K	37	41.9	517.2	39.2	478.0	
SUBTOTALS		639.5	7889.7	1664.4	6225.3	
				REGION 5		
5A	38	34.2	421.8	75.9	345.9	
5B	39	46.4	572.3	38.6	533.7	
5C	40	46.4	572.3	57.1	515.2	

Fig. 3-6 — Sample Output Report R_{11}

5D	41	46.4	572.3	26.2	546.1
5E	42	12.9	159.1	3.0	156.1
5F	43	156.0	2048.0	285.9	1762.1
5G	44	20.9	258.4	0.0	258.4
5H	45	59.0	727.5	43.4	684.1
5I	46	166.0	2049.0	96.2	1951.7
5J	47	27.7	341.5	4.6	335.9
5K	48	27.7	341.5	1.0	340.5
5L	49	16.2	199.7	4.5	195.1
5M	50	34.2	421.8	21.6	400.1
5N	51	32.8	404.9	26.9	378.0
5O	52	22.6	279.2	1.2	278.0
SUBTOTALS		759.3	9368.2	686.2	8682.0

REGION 6

6A	53	104.7	1291.5	94.5	1197.0
6C	54	83.4	1029.4	3.0	1025.4
6D	55	83.4	1029.4	2.5	1025.9
6E	56	77.8	959.9	6.5	953.4
6F	57	104.7	1291.5	111.7	1179.8
6G	58	104.7	1291.5	26.1	1265.4
6H	59	114.7	1415.5	5.6	1410.0
6I	50	118.2	1458.4	63.3	1395.1
6J	51	95.2	1174.3	4.9	1169.3
6K	52	104.7	1291.5	59.5	1232.0
6L	53	114.7	1415.5	21.4	1394.1
SUBTOTALS		1106.1	13646.5	399.0	13247.4
TOTALS		4422.8	54567.8	8695.6	45872.2

----------PERCENT SUMMARY TABLE----------

STRATEGY - MIN COST SUBJECT TO NATIONAL TOTAL ACCESSION REQUIREMENT 54568.
SUPPLY LIMITED TYPES 1 , 2 - CAT123AHSG 161100 TOTAL REQ. WITH 33.3 PERCENT SUPPLY RECR. ELASTICITY = .835 . UNEMPL. = 7.7

TOTAL ACCESSIONS

	RECRUITERS	ACCESSIONS	TYPE 1	TYPE 2	TYPE
REGION 1					
SUBTOTALS	11.3	11.3	1.0	10.3	
REGION 3					
SUBTOTALS	32.0	32.0	9.9	22.1	
REGION 4					
SUBTOTALS	14.5	14.5	3.1	11.4	
REGION 5					
SUBTOTALS	17.2	17.2	1.3	15.9	
REGION 6					
SUBTOTALS	25.0	25.0	.7	24.3	
TOTALS	100.0	100.0	15.9	84.1	

Fig. 3-6 (continued)

DRC 1A, Albany, N.Y., Region one

Unemployment rate	8.3%
Attitude factor	40.0%
Portion black	2%
Portion white	98.0%

Then for Albany:

$$CAT123AHSGB_1 = (.02)\ (.604403)\ (8.3)^{.419138} . (40)^{.72482} . (Recruiters_1)^{.835798}$$
$$= .42\ (Recruiters)^{.835798}$$

$$CAT123AHSGW_1 = (.98)(.604403)\ (8.3)^{.419138} . (40)^{.72482} . (Recruiters_1)^{.835798}$$
$$= 20.84\ (Recruiters)^{.835798}$$

The cross-section analysis average unemployment rate was 7.1% for FY75. If unemployment were increased to 7.7% or 1.0845 times the average, then the coefficients are multiplied by $(1.085)^{.419138)} = 1.0345$. Thus the equations used for DRC 1A in region one for an average unemployment of 7.7% are:

$$CAT123AHSGB_1 = .44\ (Recruiters_1)^{.835798}$$

$$CAT123AHSGW_1 = 21.56\ (Recruiters_1)^{.835798}$$

Given 46 recruiters the expected CAT123AHSGB content at DRC 1A is about 10 and for the equivalent white content 529.

These enlistment supply equations for all other DRCs are evaluated in a similar manner. Specific content such as CAT123AHSG combat arms, for example, is evaluated using historical proportions to modify the basic enlistment supply equations.

A brief discussion of Fig. 3-6—Sample Output Report R_{11} follows:

The overall optimization strategy (National) is indicated in the heading. The minimum cost in this case is the number of recruiters since unit cost is directly related to recruiters. The national total accession requirement for CAT123AHSG was 54,568 which constituted almost 34% of a total requirement of 161,000 accessions. The recruiter elasticity and average unemployment rate are announced at .835 and 7.7%, respectively.

A detailed breakout of the CAT123AHSG combat arms accessions is given DRC by DRC with subtotals by region and grand total nationally. Type one

is CAT123AHSG black and type two is CAT123AHSG white. Notice that a total recruiter force of 4,423 is required to meet the national goal of 54568 total CAT123AHSG accessions.

A percent summary table completes the report. This section of the output report describes the complete Regional distribution of the optimal national recruiter allocation and associated breakout by type. It can be noted that if the objective was to find the optimal recruiter force allocation to meet a specified CAT123AHSG combat arms requirement (Report R_{44}) that fewer recruiters would be required to attain the 13132 combat arms accessions. In fact, a requirement of 12400 CAT123AHSG combat arms accessions can be met with a recruiter force of 3421. However, this recruiter allocation only yields a national total of 39393 total CAT123AHSG accessions.

There are several different uses of the ORAM—some of which are mentioned briefly here. Perhaps foremost on the list of uses of the ORAM is assessing the effects that a range of requirements for specified accession groups have on determining the recruiting force size and mix. Another important use is concerned with the effects that changing environmental factors have on the recruiting force and the accession groups. Changes in unemployment, for example, modify the productivity of the recruiter. The output reports discussed above assumed an average unemployment rate of 7.7%. If the unemployment rate were higher a slightly smaller recruiter force would have been required. Finally, mention of the potential use of the ORAM for budgeting uses should not be overlooked. Departures from or modifications of basepoint budgets for the recruiter/canvasser programs can be investigated by using the ORAM.

4 THE MERGE/BMD TIME SERIES REGRESSION MODEL

4.1 GENERAL

The MERGE/BMD time series regression model has evolved to its present form through a series of studies concerned with the accession programs of the military services. It is structured around an extensively modified version of the UCLA Biomed stepwise regression program.* These modifications have been concerned with the application of regression analysis to time series data and, in particular, to military accession data. The model discussed in this chapter is presently operational on the USAREC UNIVAC 1108 computer system. The operational aspects of the documentation pertain specifically to that system.

4.2 METHODOLOGICAL CONSIDERATION FOR MODEL APPLICATION TO U.S. ARMY ACCESSION ANALYSIS

The regression model that has been developed for accession analysis is a nonlinear regression model. The analysis assumes the dependent variable time series is initially in unadjusted or "seasonalized" form and the independent variables do not reflect the seasonal variation apparent in the observed values of the dependent series. Yearly data which are subject to periodic fluctuations are of this type. The model is solved yielding the adjustment factors (seasonal factors) simultaneously with the parameters of the ordinary linear model. Two models result from the above analysis: the first looks upon the solution as a deseasonalization of the dependent variable and yields a least squares fit to the deseasonalized variable (this is the model solved by the program); the second considers the adjustment factors as weights for the linear portion of the model and is used for prediction purposes.

4.3 THE MODEL

(D1) A dependent variable Y (a (n x 1) vector) which is typically a time series

(D2) An independent variable data set X (a (n x p) matrix)

(A1) The number of observations of the (seasonalized) dependent variable Y is considerably longer than one cycle of the seasonal period (say at least two cycles)

---

*Dixon, W. J., ed., "BMD Biomedical Computer Programs," Health Sciences Computing Facilities, University of California, Los Angeles, 1964.

(A2) The data set X does not reflect the seasonal variation contained in the observed values of Y

Two models, M1 and M2, with separate objective functions can be developed from the above assumptions. They are:

$$\text{(M1)}\quad \underset{S^{-1},\beta}{\text{minimize}}\ f_1(S^{-1},\beta) = ||S^{-1}Y - X\beta||^2 \quad *$$

where S^{-1} is a $(n \times n)$ diagonal deseasonalization matrix

β is a $(p \times 1)$ parameter vector

$$\text{(M2)}\quad \underset{S,\ \beta}{\text{minimize}}\ f_2(S, \beta) = ||Y - SX\beta||^2$$

Ordinary linear regression analysis assumes S is the identity matrix and one solves for the parameter vector β. This is not the case here however. Model M1 assumes that Y is deseasonalized by S^{-1} and yields a least squares fit of $X\beta$ to the deseasonalized vector $S^{-1}Y$. Model M2 considers S to be an adjustment matrix which in turn modifies the linear portion $X\beta$ to form $SX\beta$ as a least squares approximation to Y. Both models are nonlinear since f_1 and f_2 are nonlinear functions over the full (S,β) space.

---

*For simplicity, the diagonal elements (seasonal factors) S_{ii} of S replace an earlier notation and are defined by

$$S_{ii} = \prod_{j=1}^{r} \exp\{b_i \delta_{ij}\}$$

where $\delta_{ij} = \begin{cases} 1 & i=j \\ 0 & i \neq j \end{cases}$, and

b_i is the seasonal coefficient for month i.

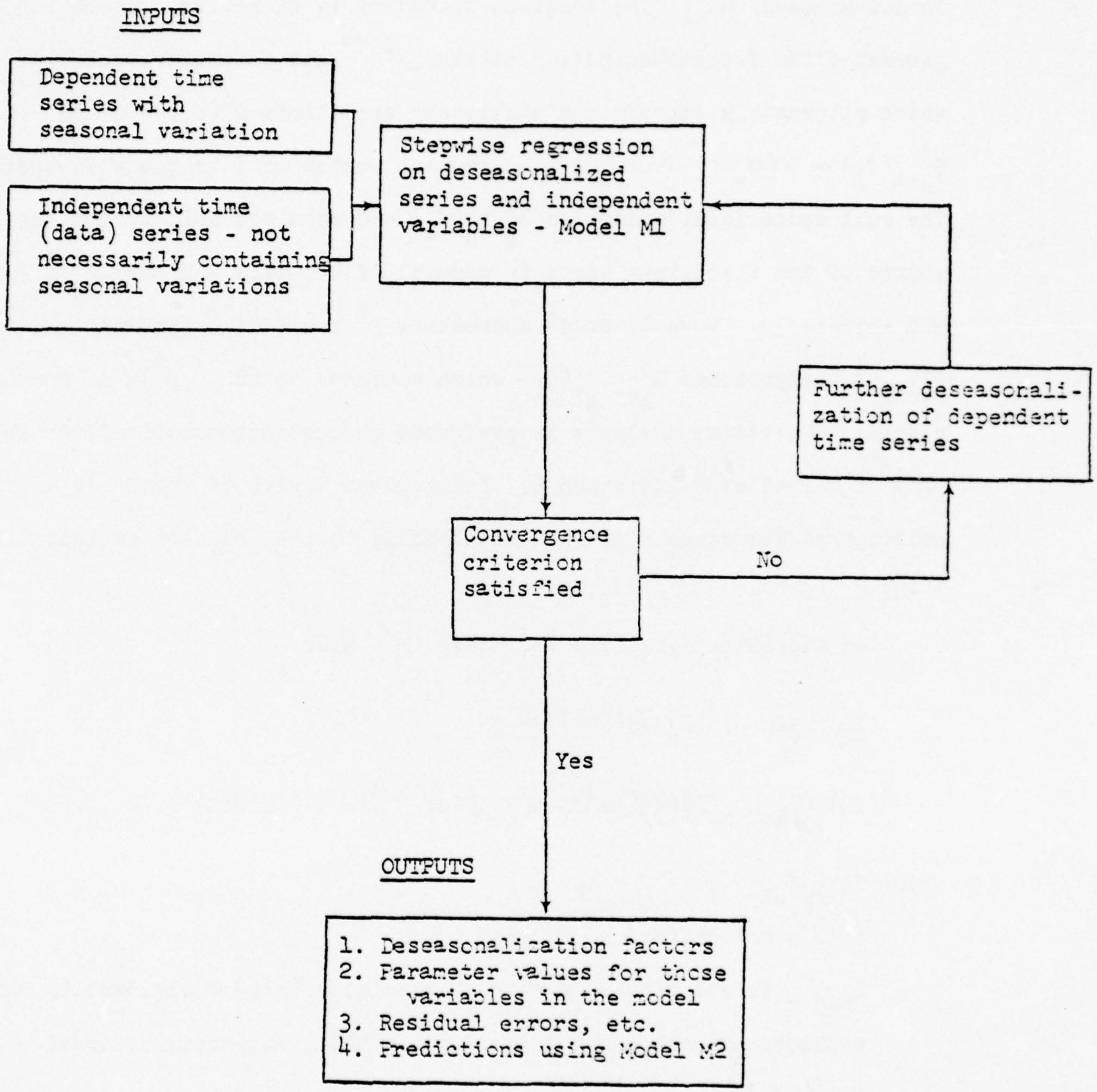

Fig. 4-1 —The Deseasonalized Step Regression Model Basic Cycle

4.4 THE SOLUTION PROCEDURE

A sequence of deseasonalization, and stepwise regressions is used to solve model M1 . The solution procedure is iterative. Iteration i generates the deseasonalization matrix $(S^i)^{-1}$ and parameter vector β^i which alternately satisfy the stationary conditions $G^i_\beta(f_1) = 0$ and $G^i_{S^{-1}}(f_1) = 0$ [$G_w(f)$ denoting the gradient vector of f in the w subspace]. The full space joint condition $G^i_{S^{-1}\beta}(f_1) = 0$ does not hold during the course of the iterations since in general if $G^i_{S^{-1}}(f_1) = 0$ then $G^i_\beta(f_1) \neq 0$ and conversely. However as β^i approaches β^* and $(S^i)^{-1}$ approaches S^{*-1}, $G^i_{S^{-1}\beta}(f_1)$ approaches $G_{S^{*-1}\beta^*}(f_1)$ which vanishes at (S^{*-1},β^*). A complete stepwise regression analysis is performed on the deseasonalized variable $(S^i)^{-1}Y$ during each iteration i. Independent variables which are in the solution at iteration i are not necessarily in the solution at iteration i + 1.

The iteration equations for model M1 are:

(I1) $\beta^i = (X'X)^{-1}X'(S^{i-1})^{-1}Y$

(I2) $I_{\text{mod } r}\ \text{Diag}\{[(S^i)^{-1}Y - X\beta^i]Y'\}\vec{1} = 0$ (matrix)

where $S^0 = I_n$

$\vec{1}$ is a column vector of ones

$I_{\text{mod. } r}$ is a n matrix of rank r containing [n/r] full identity submatrices of rank r and a residual identity submatrix of order n - [n/r]r

r is the period of one cycle.

The constraint (C) below is arbitrarily imposed on the deseasonalization elements to allow uniformity of solutions for comparitive purposes.

$$(C)\ \sum_{j=k}^{k+r} S_{jj} = r$$

Constraint (C) means that the sum of the diagonal elements of S over any cycle is normalized so that the parameter vector β will absorb the major part of the solution, and the average value of S_{jj} over one cycle is $1/r$.

The iteration process is terminated when condition (T) below holds.

$$(T)\ |\ S^{i-1}(S^{i})^{-1} - I_n| \leq \text{Diag}\ \varepsilon, \text{element by element}$$

where ε is prescribed (currently .001).

Table 4.1 contains the gradient vectors and Hessian matrices for f_1 and f_2 of models M1 and M2 respectively. f_1 has a positive semi-definite Hession for non-negative data and thus model M1 can be solved as a convex problem. This is not the case with model M2.

Table 4.1

GRADIENTS AND HESSIANS

$$f_1 = \|S^{-1}Y - X\beta\|^2$$

$$G_\beta(f_1) = -2X'(S^{-1}Y - X\beta)$$

$$G_{S^{-1}}(f_1) = 2\, I_{\text{mod } r}\{\text{Diag}[(S^{-1}Y - X\beta)Y']\}\vec{1}$$

$$H_{\beta x\beta}(f_1) = 2X'X$$

$$H_{S^{-1}xS^{-1}}(f_1) = 2\, I_{\text{mod } r}\, \text{Diag}\,[YY']$$

$$H_{S^{-1}x\beta} = -2\, I_{\text{mod } r}\{\text{Diag}\,[Y]\}X$$

$$f_2 = \|Y - SX\beta\|^2$$

$$G_\beta(f_2) = -2(SX)'(Y-SX\beta)$$

$$G_S(f_2) = -2\, I_{\text{mod } r}\{\text{Diag}\,[(Y - SX\beta)(X\beta)']\}\vec{1}$$

$$H_{\beta x\beta}(f_2) = 2(SX)'(SX)$$

$$H_{SxS}(f_2) = 2\, I_{\text{mod } r}\{\text{Diag}[(X\beta)(X\beta)']\}\vec{1}$$

$$H_{Sx\beta}(f_2) = -2\, I_{\text{mod } r}\{[\text{Diag}\,(Y)]X - 2[\text{Diag}\,(X\beta)]SX\}$$

4.5 REGRESSION PROBLEMS WITH FIXED ELASTICITIES

If each variable appearing in the regression model is normalized by dividing each variable (including the dependent variable) by its mean value, then the following corresponding coefficients e_k are called the elasticities for the kth variable. The deseasonalized regression model becomes

$$\frac{S^{-1}Y}{\overline{S^{-1}Y}} = e_o + e_1 \frac{X^1}{\overline{X^1}} + \ldots + \frac{e_1 \ X^p}{\overline{X^p}}$$

where the superscript K on X indexes the vector X^k with n components (observations) and S^{-1} is the nxn diagonal deseasonalizing matrix.

Then, if $e_o \neq o$

$$e_o = \left(\frac{S^{-1}Y}{\overline{S^{-1}Y}}\right) - \sum_{k=1}^{p} e_k \left(E \frac{X^k}{\overline{X^k}}\right)$$

$$= 1 - \sum_{k=1}^{p} e_k$$

where E is the expected value operator, thus

$$\sum_{k=o}^{p} e_k = 1$$

The relation between e_k and the ordinary coefficients β_k is as follows:

For $S^{-1}Y = b_o + \sum_{k=1}^{p} \beta_k X^k$

if $\beta_o \neq o$ then

$$B_o = \overline{S^{-1}Y} - \sum_{k=1}^{p} \beta_k \overline{X^k}$$

and $\beta_k = \frac{\overline{S^{-1}Y}\, e_k}{\overline{X^k}}$ or $e_k = \frac{\beta_k \overline{X^k}}{\overline{S^{-1}Y}}$ $(k = o,\ldots,p)$

Frequently it is desired to fix one or more of the elasticities of a set of variables and formulate a regression problem on the remaining set of variables. Such problems are considered in the following manner.

If we assume q elasticities e_k $(k=1,\ldots q), q < p$, are prescribed, then

$$S^{-1}Y = \beta_o + \left(e_i \frac{\overline{S^{-1}Y}}{\overline{X^1}} X^i + \ldots + e_q \frac{\overline{S^{-1}Y}}{\overline{X^q}} X^q\right) + \beta_{q+1}X^{q+1} + \ldots + \beta_p X^p$$

is the deseasonalized model with q fixed elasticities and p-q independent variables.

The coefficients $\beta_{q+1},\ldots\beta_5$ and deseasonalized matrix S^{-1} are found by solving the equation

$$\min F = \Sigma\, (Z_i - \hat{Y}_i)^2 \quad \beta_{q+1},\ldots \beta_p \quad S^{-1}$$

$$\text{where} \quad Z_i = S_i^{-1} Y_i - \overline{S^{-1}Y}\left(\frac{e_1 X_i^1}{\overline{X^1}} + \ldots \frac{e_q X_i^q}{\overline{X^q}}\right)$$

$$Y = \beta_o + \beta_{q+1}X^{q+1} + \ldots + \beta_p X^p.$$

4.6 MERGE/BMD TIME SERIES REGRESSION MODEL OPERATIONAL DOCUMENTATION

General system flow diagrams for PROGRAM MERGE (Figure 4.2) and PROGRAM BMD (Figure 4.3) are presented here at a level sufficient to describe the general input-output flow of information. Tabular descriptions of the I/O units used by PROGRAM MERGE (Table 4.2) and PROGRAM BMD (Table 4.3) are also included.

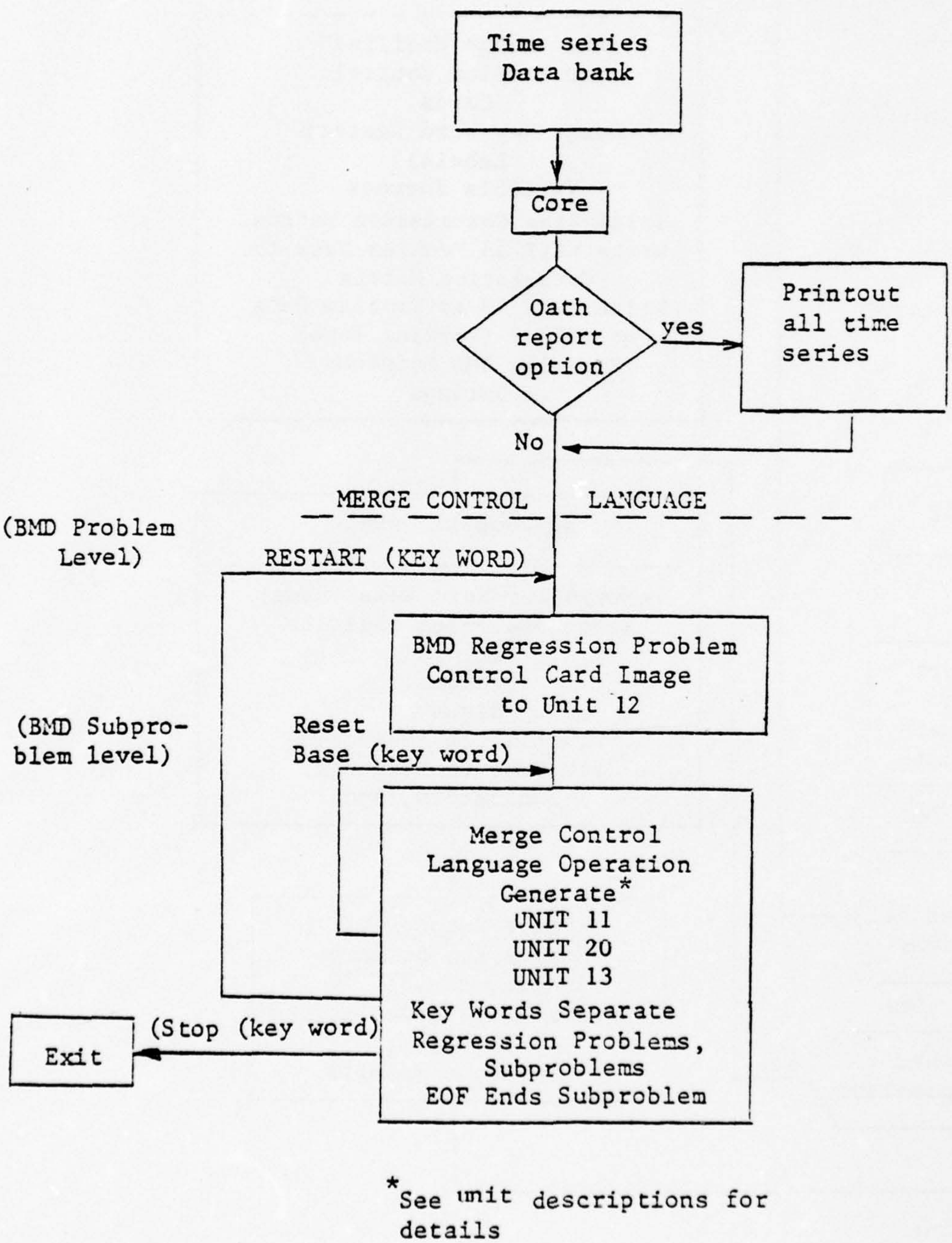

Fig. 4.2— PROGRAM MERGE General Flow Diagram

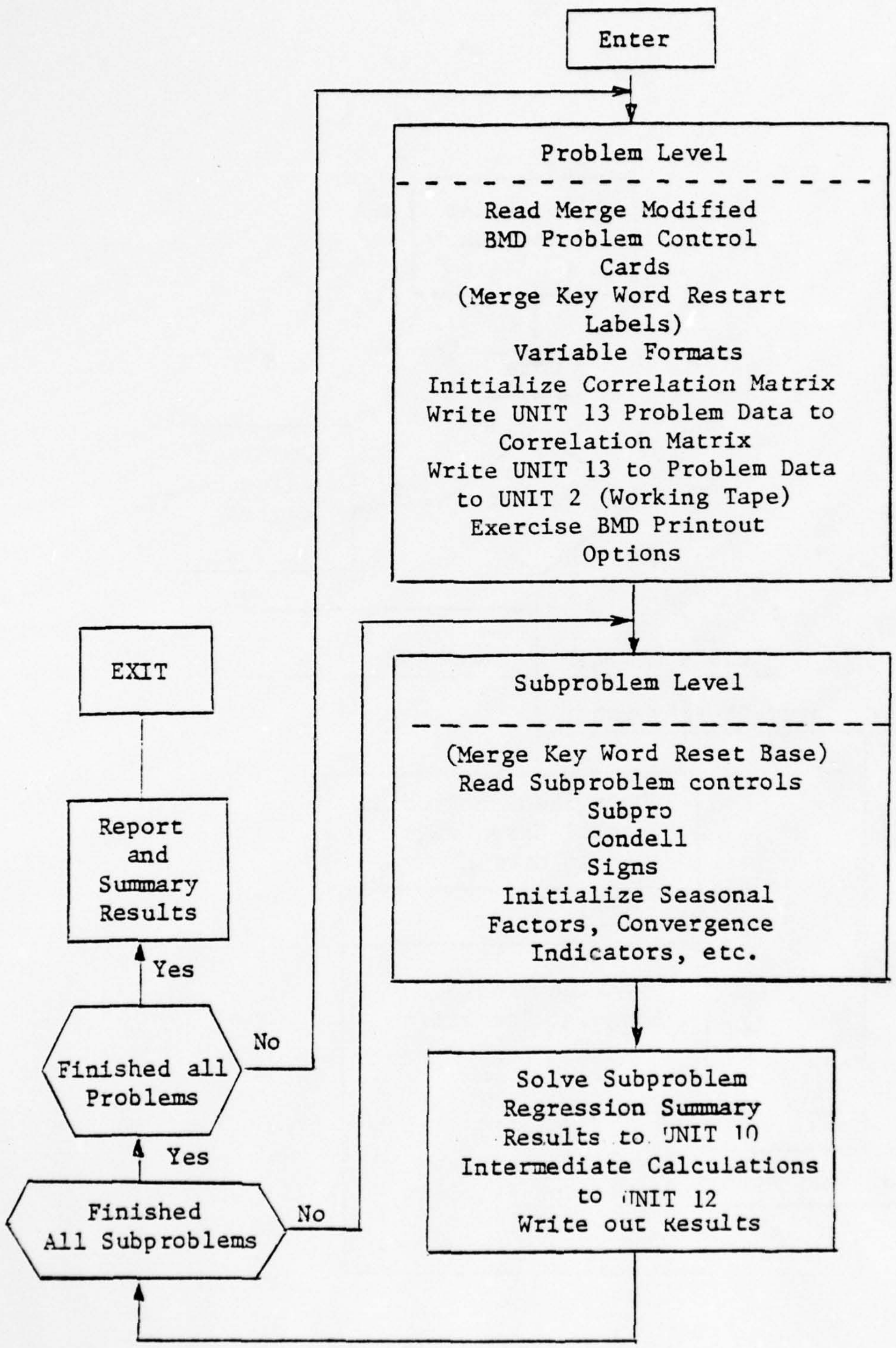

Fig. 4.3— PROGRAM BMD General Flow Diagram

Table 4.2

I/O UNITS USED BY PROGRAM MERGE

Unit Used	Description	General Purpose	Format
12	Time series data bank—up to 96 different time series with up to 4.5 years of monthly data per series	Data bank from which regression problems are formulated using the MERGE CONTROL LANGUAGE	Header 20X, 215, A10 Series Names 8A10 Data A10, 215, F10.0
5	Input tape	BMD regression problem control cards	Variable
6	Output tape	Printer output messages from PROGRAM MERGE	Variable
13	Data tape for particular regression problems (data sets) set up by MERGE CONTROL LANGUAGE	Selects appropriate time series from input unit using MERGE CONTROL LANGUAGE TO GENERATE data sets for regression problems	Variable
10	MERGE working tape	Sets up images of BMD regression problem control cards (tape 5) for modifications by MERGE CONTROL LANGUAGE—used in conjunction with unit 20	See BMD CONTROL LANGUAGE
11	Regression problem variables, time series names, and monthly time lags, problem by problem	Summaries for each regression problem the names and monthly shifts for each time series variable	Unformatted
20	MERGE modified BMD problem cards	Modifies BMD regression problem control cards and sets up input unit 20 for input to the modified BMD program	See BMD CONTROL LANGUAGE

Table 4.3

I/O UNITS USED BY PROGRAM BMD

Unit Used	Description	General Purpose	Format
12	BMD working tape	Intermediate calculations	Unformatted
2	BMD regression problem data tape	Working tape used to store the regression problem set data for each problem using tape 7 as prepared by PROGRAM MERGE	Unformatted
20	MERGE modified BMD regression problem CONTROL card images	BMD regression problem control card images as modified by PROGRAM MERGE	See BMD CONTROL LANGUAGE section IV
6	Output	BMD printer output messages	Variable—usually alphanumeric
13	BMD regression problems data tape	Stores data needed for regression problem sets (problem by problem)	Variable
11	Regression problem variables, time series names and monthly lags, problem by problem	Summarizes for each regression problem the names and monthly shifts for each time series variable	Unformatted
10	Summary of regression results (working tape)	Working tape used to summarize regression problem results for report printout when all problems are finished	Unformatted

4.7 BMD CONTROL LANGUAGE

A detailed description of the BMD CONTROL LANGUAGE and its use is contained in this section. BMD CONTROL LANGUAGE WORDS are listed in Table 4.4.

Table 4.4

BMD CONTROL LANGUAGE IN ORDER OF OCCURRENCE
IN A PROBLEM SPECIFICATION

Card	Type	Remarks
1	PROBLM	See Table 4.5
2	LABELS	
3	format	(10X,10F12.4/(10X,10F12.4))
4	SUBPRO	See Table 4.6
5	CONDEL	See Table 4.7
6	blank card	Mandatory
7	IDXPLT	Optional
8	FINISH	

Cards 4-7 are repeated for each additional subproblem.

Specifying the BMD Control Cards

BMD control cards will be entered in the following sequence, either initially or following the control card RESTART (key word). That is, these cards are read once initially and used for every regression problem until a RESTART card is read (p. 4-31). The control cards are unchanged from their BMD specifications, with the exception of column 70, which still applies; however, they are revised automatically for every run by MERGE to incorporate the data counts and label counts. The actual cards generated are listed in MERGE output.

PROBLM Card

This should be completed according to Table 4.5. The variable count, observation count, prediction count and labels count are rewritten to reflect the contents of the data files and the variables used in this run. The prediction count reflects the remainder of the 54 points in each time series, which occur after the last actual observation. All data is stretched using sample and hold in (p. 4-21), and residual calculation is used to predict the dependent variable for the values of the independent variable.

Table 4.5

SPECIFICATIONS FOR PROBLM CARD

Column	Entity	Remarks
1-6	'PROBLM'	Mandatory
7	Report Title	Set equal to 1
8	Filler	Blank
9	Print control	3 suppresses intermediate output; 2 or less prints details of each step in the regression
10-15	Problem name	6 alphanumeric characters
17-20	Sample size	Leave blank. Will be computed by MERGE
24-25	p, number of original variables	Leave blank. Will be computed by MERGE
29-30	m, number of TRNGEN cards	$0 \leq m \leq 99$
34-35	q, number of generated variables	$-9 \leq q \leq 78$
39-40	Unit number if data is on an input medium other than cards	*blank - if card input; 13 - otherwise*
44-45	s, number of subproblem cards	$1 \leq s \leq 99$
48-49	Number of variables labeled on LABELS card	Leave blank. Will be computed by MERGE
51-53	Output switch	'YES', if means and standard deviations are to be printed; blank, otherwise.
55-57	Output switch	'YES', if covariance matrix is to be printed; blank, otherwise
59-61	Output switch	'YES', if correlation matrix is to be printed; blank, otherwise.
63-65	Output switch	'YES', if zero regression intercept is desired; blank, otherwise
68-69	Input switch	'NO', if tape specified in columns 39-40 is not to be rewound before this problem; blank, if columns 39-40 are blank or Y tape rewind is desired.
70	Operational mode	See Section 4.9

Table 4.6

SPECIFICATIONS FOR SUBPRO CARD

Column	Entity	Remarks
1-6	Identifier	'SUBPRO' (mandatory)
9-10	Dependent variable ID	This is the variable number assigned in MERGE processing. Ordinarily the dependent variable should be the first variable in the variable list and accordingly '1' should appear in column 10.
13-15	Maximum number of steps allowed in stepwise regression	If this is left blank, the default is one step per variable. Both original variables and variables generated by lags or 'CREATE' are considered in computing the default value.
20-25	F-level for inclusion	This will be .01 if left blank.
30-35	F-level for deletion	This will be .005 if left blank.
40-45	Tolerance level for comparisons	This will be .001 if left blank.
49-50	Number of variables on the index-plot card	This must be between 0 and 30.
53-55	CONDEL switch	'YES' if CONDEL cards are included
58-60	Residuals switch	'YES' if a list of residuals is to be printed
63-65	Summary switch	'YES' is a summary table is to be printed

Table 4.7

SPECIFICATIONS FOR CONDEL CARD

Column	Entity	Remarks
1-6	Identifier	'CONDEL' (mandatory)
7	Control value* for 1st variable	
8	Control value* for 2nd variable	
. . .		
72	Control value* for 66th variable	

---

*Control values are

1 - Delete variable from consideration
2 - Free variable
3 - Low-level forced variable
4 - Higher-level forced variable

. . .

9 - Highest-level forced variable

Values 3-9 allow prioritizing of the entry of variables into the regression

LABELS Card

A blank LABELS card must be included to signal where the labels are required in the deck. The appropriate labels are generated from the variable specified by using the first 6 characters of each name.

Format Card

The format card is fixed by MERGE and should be:

(10X, 10F12.4/(10X, 10F12.4))

in columns 1 - 27.

SUBPRO Card

The SUBPRO card should be completed according to Table 4.6. It is convenient to make the dependent variable 1, but this is not a restriction.

CONDEL Card

The CONDEL card follows Table 4.7 specifications. The card also signals the creation by MERGE of 2 additional cards defined below, both of which are new.

LIMITV Card

The LIMITV card notes the variable count limits, if any.

SIGNS Card (Coefficient Sign Restriction)

The SIGNS card records the sign controls for the variables, if any.

TITLE Card

In addition there is now a title card, which may be blank, and permits step print suppression and provides a run title for all runs. If the card is blank the independent variable title is used.

Cols	Entity	Remarks
1-2	Print control	Specifies step to store printing (only valid if print not suppressed on problem card, Table 4.5)
3-74	Title	Leave blank unless desired title different than dependent variable

Example: (03 C123 - combat arms categories, 1, 2 and 3)

This would have the effect of starting the regression printout at Step 3 and provides a title printed bold-face across the leading page.

IDXPLT Card (optional)

The IDXPLT card follows Table 4.8 specifications. This card is required if columns 49-50 of the subproblem card are greater than 0.

FINISH Card

The file is terminated by a FINISH card.

Table 4.8

SPECIFICATIONS FOR IDXPLT CARD

Column	Entity	Remarks
1-6	Identifier	'IDXPLT' (mandatory)
7-8	Number of 1st variable to be plotted	
9-10	Number of 2nd variable to be plotted	
	. . .	
65-66	Number of 30th variable to be plotted*	

*No more than 30 variables may be plotted per subproblem.

4.8 MERGE CONTROL LANGUAGE

The MERGE Control Language is listed in Table 4.9. A detailed discussion of the language and its use is presented in this section.

Defining a Variable Time Series for MERGE

MERGE recognized any appropriate data defined by the rules of this section as a legitimate time series.

Input Data for the Variable Time Series

This is done by card (or card image) input and is read in on input Unit 5. The first card defines the first data occurring in any time series, and a list/no-list option.

Time Series Initialization Card

Column	Entity	Remarks
1-20	Filler	May be used as data stream identifier field
21-25	Year	Starting year of all time series (right justified)
26-30	Month	Starting month of all time series (right justified)
31-34	Filler	
36-40	List option	Right justified values: LIST - causes listing of all time series NOLIST - suppress listing
41-80	Filler	

Table 4.9

MERGE CONTROL LANGUAGE
(order of precedence)

Time Series Initialization Card Title card for time series input Time series data input END	Repeated for every time series (max. 99)
LAST FILE	
(BMD Control Cards)	
BASE	
CREATE	
Variable creation cards	
TREND (optional)	
END	
Dependent variable name (Table 4.10) Independent variables (Table 4.10) DUMMY (Additive optional seasonals) SET	Repeated for additional sets of variables
Independent variables to be included in subsequent runs	
END	
NEW DEPVAR (optional)	
New independent variable (Table 4.10)	
END	
RESTART (optional)	
New variable set (dependent and independent variable) (Table 4.10)	
END	
RESET BASE (optional)	
New BASE card	
END	
STOP	

Each time series consists of at least three cards:

(a) The first card is a title card used to title the printout if a listing is desired.

(b) The second and subsequent cards each define the data point from a specific time and held to the end of the time series of 54 months. This simplifies data definition.

(c) The last card of each time series consists of the key word END entered in columns 1-3. An example of a time series is displayed in Fig. 4.4. The name on the last data card entered for each time series, names the series, a feature which makes it easy to change a name to suppress a file, for example.

```
HSG           MALE,NPS,HSG CONTRACTS FOR REGION 1
HSG             1   73 1221.0000
HSG             2   73 1261.0000
HSG             3   73 1069.0000
HSG             4   73  637.0000
HSG             5   73  616.0000
HSG             6   73  955.0000
HSG             7   73 1150.0000
HSG             8   73 1160.0000
HSG             9   73 1041.0000
HSG            10   73  836.0000
HSG            11   73  797.0000
HSG            12   73  644.0000
HSG             1   74 1123.0000
HSG             2   74  837.0000
HSG             3   74       884.0
HSG             4   74       871.0
HSG             5   74       839.0
HSG             6   74      1075.0
HSG             7   74       911.0
HSG             8   74      1100.0
HSG             9   74      1054.0
HSG            10   74 1202.0000
HSG            11   74 1161.0000
HSG            12   74 1019.0000
HSG             1   75 1602.0000
HSG             2   75      1225.0
HSG             3   75 1563.0000
HSG             4   75 1528.0000
HSG             5   75 1477.0000
HSG             6   75 1933.0000
HSG             7   75 1429.0000
HSG             8   75 1661.0000
HSG             9   75 1689.0000
END
```

Fig. 4.4— Xeroxed Listing of Time Series

Time Series Definition Cards (N months of data)

Card	Columns	Entity	Remarks
First	1-72	Title	Descriptive title of time series
2nd and	1-6	Name	Time series name
following	5-10	Filler	
.	11-15	Month	Month of data - right justified
.	16-20	Year	Year of data, two digits - right justified
.	21-30	Data	Numerical value of data, decimal point must be present
Last	1-3	Name	'END'

Additive seasonal variables are stretched periodically, as appropriate, if the first four characters of their name are SEAS; otherwise, they are stretched using the above sample and hold technique.

The end of all time series input is indicated by the card LAST FILE, where cols 1-4 - LAST and 7-10 - FILE.

Obtaining a Data Listing

If the LIST option is entered on the first data card, all of the time series are tabulated in a form suitable for Xerox.

Selecting Data for the Regression

This is done by specifying the names of the time series desired, in the order desired with additional variable control information.

BASE Selection

The first card for the run must specify the first and last data points to be used in the dependent variable time series.

Columns	Entity	Remarks
1-4	BASE	may be blank
5-10	Filler	
11-15	First year	Beginning year of data for analysis (2 digits, right justified)
16-20	First month	Beginning month of data for analysis (right justified)
21-25	Last Year	Last year of data
26-30	Last month	Last month of data

Variable Selection

This is performed by control cards specifying the file names in the order desired. All names must start in column 1 and should be no more than 6 characters long.

Example:
```
C123
MILPAY
CA-OPT
BNS-CA
```

This will set up a data file for BMD with four variables as specified, using the assumptions that the first variable is the dependent variable. Additional runs can be generated by further "files" of control cards, exactly as above, in which each variable is mentioned explicitly. In every case, the data used will extend from the first to the last data point specified on the BASE card.

Repeated Variable

Repeated variable sequences can be set up very easily for use in several subsequent runs by using a SET card which simply preserves, as a base, all preceding cards in that file of control cards.

example:
```
C123
MILPAY
BNS-CA
CA-OPT          run 1
SET
ADVT
END

PAID TV
END             run 2

RECR
END             run 3
```

This sequence will set up three five-variable runs in which the first four variables are always the same but in which the last variable is changed each time. The point of this is to reduce the number of cards required.

The SET card will also incorporate additional cards in a previous setting which allows the user to gradually extend his base case. The setting continues until either a RESET BASE card or a RESTART card is encountered.

RESET BASE (Key word)

The RESET BASE key word in columns 1-10 clears the setting of SET and returns control to the base specification point, from any point in the control card sequence.

Shifted Time Series (Leads and Lags)

MERGE was originally constructed to permit generation of multiple copies of time series with various shifts so that regressions with leading and lagged data could be performed easily.

If the shifts are listed on the variable cards, they are generated automatically.

Example: MILPAY -3 -2 -1

will include four variables, all copies of MILPAY with lags of -3, -2, -1, and 0 months relative to the dependent variable. 0 is always included unless the last entry is 99.

example: MILPAY -2 99

will include one copy of MILPAY with a lag of 2 months, relative to the dependent variable.

Coefficient Sign Control

Coefficient sign control can be obtained by adding a P, N or blank to the variable card, for positive, negative or free sign control respectively. This means that the variable and any of its copies generated from this card will enter the regression only if its initial coefficient sign is positive or negative as requested on the card. This is done by checking the sign of the partial correlation coefficient of the variables currently out of the regression. This overrides CONDEL specification.

Variable Limit

With several copies of a variable with different lags in the regression calculation, it is convenient to limit the number which can actually enter the equation. This is done by specifying a limit on the variable card of 1, 2,...up to 9, and this limits the count of variables which may actually enter the equation.

Note that the variables are entered in order of significance at that time, so that 3 of 10 does not give necessarily the best 3 out of 10 shifts, but the first 3. Some skill is still necessary.

This restriction overrides the CONDEL card specification.

Table 4.10

VARIABLE CARD FORMAT

Columns	Entity	Remarks
1-6	Variable name	Left justified
7-10	Filler	
11	Initial sign to enter	P = positive N = negative blank = either
12	Variable count	Maximum number of lagged variables with this name allowed to enter the equation
14-15	Shift 1	Positive of negative
16-20	Shift 2	Shifts of variable,
21-25	Shift 3	99 restricts unlagged
:		variable from equation
61-65	Shift 10	Optional

As many as 10 shifts may be entered on one card, positive or negative, with 0 or "no lag" added on the end unless suppressed with a 99. It is the user's responsibility to ensure that shifted data is still within the range of the time series definition by adjusting the base card setting.

STOP Card for MERGE

The STOP keyword in columns 1-4 ends MERGE so that BIOMED can be run. At this state BIOMED receives its data on file 13, its control cards on file 20 and certain report generator data on file 11.

DUMMY (Additive Seasonals)

The DUMMY keyword in columns 1-5 serves to automatically generate 12 additive seasonal dummies labelled JAN through DEC. MERGE uses a standard dummy file DMMY12 and introduces 12 leads of 0 through 11 to generate the months. Thus DUMMY introduces 12 variables and the CONDEL and TRANGN cards of BMD02R should note this in indexing the variables.

MERGE Output

MERGE lists the cards accepted and, if the LIST option is taken, lists the data retrieved for each regression run setup.

CREATE - Creation or Modification of Variables

The key words CREATE and END read in (A6) format signal that the group of cards beginning with CREATE and ending with END create new variables or modify an old variable using simple scaling of variables. This is equivalent to transgeneration cards but simpler to use. The formats of the cards are given in Table 4.11

The specific options offered under CREATE are detailed below.

Columns	Entity	Remarks
1-6	New name*	Name of variable to be created
7	=	Equality sign
8	-	-
9-15	Scale factor	Multiplicand scaling factor
16-18	*	Indicates multiplication
19-24	Variable name	Variable scaled by preceding multiplicand
25-26	Shift	Positive or negative shift of value range (-9, +9)
27-33	Scale factor	All products are summed to produce the new name variable
34-35	*	
36-41	Variable name	
42-43	Shift	
44-50	Scale factor	
51-53	*	
54-59	Variable name	
60-61	Shift	
62-68	Scale factor	
69-71	*	
72-77	Variable name	
78-79	Shift	

*If new name has not occurred before, then its data is initialized to zero, a variable of name "new name" is created, with title given by the creation card itself, and whose data content is defined on the card.

If new name has occurred before, then the modifications are applied to that time series. Thus several data cards can be used to define a new time series or modify an old one.

Table 4.11

FORMAT FOR CREATE CARD

Variable scaling and linear combinations of variables

Columns	Entity	Remarks
1-6	Variable name	Variable to be created or modified
7	Filler	Blank
8	=	Equals sign or blank
9-15	Scale 1	Scale factor for first variable. Decimal point and sign must be included
16	*	Multiplication sign or blank
17-22	Variable name	Name of first variable, must exist in file or by prior CREATE operation
23-24	Shift 1	Shift for preceding variable range (-9, +9)
25-26	Filler	Blank field
27-33	Scale 2	As per scale 1
34	*	
35-40	Variable name	
41-42	Shift 2	
43-44	Filler	
45-51	Scale 3	
52	*	
53-58	Variable name	
59-60	Shift 3	As above
61-62	Filler	
63-69	Scale 4	
70	*	
71-76	Variable name	
77-78	Shift 4	
79-80	Filler	

Table 4.11 (cont'd)

Operations on CREATE variable

Columns	Entity	Remarks
1-6	Variable name	Names of variable, predefined
7-12	Operation	LIST, list variable CLEAR, set all points to zero LOGN, natural log of variable

Function in CREATE

Columns	Entity	Remarks
1-6	Variable name	Resultant variable name
7	Filler	Blank
8	=	Equals sign of blank
9-15	Scale	Scale value applied to function result
16	*	Multiplication sign or blank
17-24	Function Name	Left justified - MAX, MIN, or PRODUCT
25-26	(	Left parenthesis or blank
27-33	Scale 1	Scale value applied to first variable
34	Filler	Blank
35	*	Multiplication sign or blank
36	Filler	Blank
37-42	Variable 1	First variable name
43-44	Shift 1	Shift of variable 1 (-9, +9)
45-51	Scale 2	
52	Filler	Blank
53	*	Multiplication sign or blank
54	Filler	Blank
55-60	Variable 2	
61-62	Shift 2	
63	)	Right parenthesis
64-80	Filler	Blank field

Example: (TEMP = 1.74200 * MILPAY - 1 + 1.760Q * CA-OPTS)

which creates a new variable named TEMP from MILPAY (- 1) and CA-OPTS (0) as defined above. All entries are right-justified.

(a) The CREATE-END packet should occur immediately after a BASE card; it can occur anywhere, but must occur before the new variable or its modification is referenced. The data are not placed in the BIOMED run unless explicitly called.

(b) The new variables have all the properties of, and can be called exactly as, permanent variables. It is anticipated that this feature will be most useful for generating new dependent variables, and the BIOMED runs are titled with the mode of creation of the variable if it is new and a blank title card is used.

(c) Constants. If the variable name is absent, the scale value is treated as a simple constant.

(d) "TREND" is a reserved variable name for a ramp function taking values 1 to 54 in months 1 to 54 in CREATE only.

(e) LIST. The reserved name LIST in cc 11 to 14 causes a list of the variable specified using the report format. This is useful for spot checking the results of transformations in CREATE only.

Example: C123 LIST

(f) CLEAR. The reserved name CLEAR in cc 11 to 15 sets the specified old named variable to zero. This is done automatically for new variables.

Example: TEMP CLEAR ·

(g) Functions. Simple functions are permitted, one per card in the following format:

Function of Variable

Columns	Entity	Remarks
1-6	New name	Name of variable to be created
7-8	=	Equality sign
9-15	Scale factor	Applied to result of function
16-18	*	Multiplication sign
19-26	Desired function	PRODUCT
		MAX
		MIN
	(	Left parenthesis
27	Scale factor	Applied to following variables
	*	
	Variable name	
	Shift	
	,	Comma used for separation
	Scale factor	
	*	
	Variable name	
	Shift	
	)	Right parenthesis

The scale values and shifts can be omitted.

NEWDEPVAR - Selecting a New Dependent Variable to be Run with a Common Set of Independent Variables

The key word NEWDEPVAR in columns 1-9 is used to change dependent variables of the prior subproblem. The name of the new dependent variable follows on the next card followed by an end of file card.

```
example:  C123
          MILPAY     Run 1
          BONUS
          END

          NEWDEP                 XNEW
          XNEW       Run 2 is    MILPAY
          END                    BONUS
```

Caution:

The intended primary use of the key word NEWDEPVAR is in comparing the effects of the same programs and policies on different population groups (dependent variables). When using the special multiplicative mode operation of the seasonal model, Section 4.9, do not change programs and policies in conjunction with the NEWDEPVAR key word.

RESTART (Key word)

The key word RESTART in columns 1-8 returns control to the BMD CONTROL LANGUAGE at read in point PROBLEM p. 4-13. The SET setting (if any) is also cleared.

4.9 BMD—OPERATIONAL MODES

The modified regression program is operated in four different modes, as depicted in Table 4.12. Note that operational modes 3 and 4 require that the same set of independent variables is run against different sets of dependent variables.

Table 4.12

OPERATIONAL MODES

Operational mode	Special controls required		PROBLEM restrictions	Special set-up instructions
	PROBLM card	CONDEL card		
1	Col 70 = blank	none	none	none
2	Col 70 = M	none	none	none
3	Col 70 = E	Col 8 $\neq$ 1	Same set of independent variables	See Note 1 Section 4.5
4	Col 70 = E	Col 8 = 1	Same set of independent variables with the second variable having fixed elasticity	See Note 2 Section 4.5

1 Additive mode
2 Multiplicative seasonal mode with no restrictions on problem sets
3 Special multiplicative seasonal mode with no fixed elasticities
4 Special multiplicative seasonal mode with fixed elasticities

Note 1: The MERGE CONTROL LANGUAGE (key word) NEWDEPVAR (see Section III) is used for setting up mode 3 operation.

Note 2: The special instructions required to set up a problem for mode 4 operation are as follows:

Given fixed elasticities e_k ($k=1,\ldots,q$) for independent variable k with mean value $\bar{X}^k$, a new variable v_i is defined for each value i of the series i using the CREATE option of PROGRAM MERGE as:

$$v_i = \sum_{k=1}^{q} \frac{e_k X_i^k}{\bar{X}^k} \qquad i = 1,\ldots,N.$$

v_i must then be inserted as the second variable of the regression and run together with the remaining p-q variables.

4.10 BMD REPORTS

Summary Report

The summary report summarizes the last step of each regression and contains the following information:

a. Dependent variable
b. RSQ
c. Constant
d. List of all independent variables used in a related run series and their time shifts
e. The coefficients of each variable in the regression and Fs to remove or enter; if the coefficient is non-zero, the variable is in the regression and the F-value is the F to remove; if the coefficient is zero and the F-value is non-zero, the variable is not in the regression and the F-value is the F to enter; if the coefficient and F-value are both zero, the variable was not used in the particular run.

It should be noted that the dependent variable is assumed to be the first variable and unchanged for each run on one page. Dependent variable changes are precipitated by a RESTART or a RESET Base control card.

Residuals Report

A residual is computed as

$$\text{residual} = y - \hat{y} = y - \alpha - \sum_i \beta_i X_i$$

where

y = dependent variable

$\hat{y}$ = $\alpha + \sum_i \beta_i X_i$ is the prediction

α = constant

β_i = coefficient

X = independent variable

i = number of independent variables in the regression

b. The list of residuals has been expanded by adding future data points where the number of past and future data points is 54. The residual computation for future data points is the same as for known data points except for the setting of the variable to zero.

c. Future values of the independent variables are stored by automatically extending the last value of each time series to the full 54 points (Jan 70 to Jun 74). However:

1. If future policy changes are known, these can be added to the time series as normal data points. The base card defines the cut-off between past and future.

2. Seasonal values and dummy values need to be explicitly extended.

3. The PROBLM card is automatically revised to show the number of future points.

APPENDIX A

SETUP INSTRUCTIONS FOR USAREC UNIVAC 1108 COMPUTER SYSTEM

The purpose of this appendix is to provide instructions on utilization of the components of the USAREC Market Information Sybsystem.

A.1 Optimal Budget Allocation Model

@RUN RUNID, ACCOUNT NUMBER, PROJECT, TIME, PAGES
@TYPE (this card is required by systems software)
@PASSWD Password for System
@XQT FILENAME. OBAM
Budget Model Input Data
@FIN

A.2 Optimal Recruiter Allocation Model

@RUN RUNID, ACCOUNT NUMBER, PROJECT, TIME, PAGES
@TYPE
@PASSWD system password
@XQT FILENAME. ORAM
Recruiter Model Input Data
@FIN

A.3 MERGE/BMD Time Series Regression Model

@RUN RUNID, ACCOUNT NUMBER, PROJECT, TIME, PAGES
@TYPE
@PASSWD system password
@XQT FINENAME. MERGE
Time Series Data (see note)
BMD Control Cards
MERGE Control Cards
@XQT FILENAME. BMD
@FIN

If the user wishes to save any of the output on intermediate results that are contained in the work files, each file desired must be explicitly created.

MERGE files - the following cards must precede the @XQT FILENAME. MERGE card: @USE UNIT#, @ASG,CP NEWFILE, F/1/TRK/64, NEWFILE where NEWFILE

is a user file name in correspondence with installation standards, and unit # is one of the unit numbers presented in Table 4.2.

BMD files - the following cards must precede the @XQT FILENAME. BMD card: @USE UNIT#, @ASG, CP NEWFILE, F/1/TRK/64, NEWFILE in this case unit # corresponds to Table 4.3.

Note: The time series data could be contained on a card image mass storage file and could be inserted at the appropriate location in the runstream as follows:

```
@ADD    TSDATA.
```

where TSDATA is an example of the file name.

If multiple sets of time series exist, they could be included in one file as symbolic elements. Your system software should be able to clarify procedures for creating this type of file.

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DOCUMENTATION REPORT TO SUPPORT THE ANALYSIS FOR MANAGEMENT OF --ETC(U)
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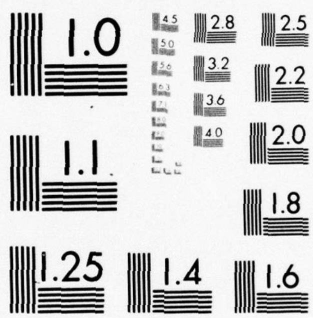

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX B

SYSTEM SPECIFICATIONS FOR USAREC 1108 COMPUTER SYSTEM

The contents of this appendix present the system resource requirements of the different components of the USAREC Market Analysis Subsystem. In addition, the subroutines and functions used in each component are presented with a short description.

B.1 Optimal Budget Allocation Model

Resource requirements

Average run time - minimum 8 CPU seconds

Core required - 12K words

Input cards - minimum 5

Output pages - minimum 10

Subroutines (presently compiled as one program with internal subroutines)

MAIN program - the main program reads the input cards and verifies parameter names.

SEARCH - performs general fibonacci minimum search.

FVAL - function of Newton method to solve for budget.

B.2 Optimal Recruiter Allocation Model

Resource requirements

Average run time - approximately 50 seconds CPU

Core required 35K words

Input cards - approximately 600

Output pages - approximately 60

Subprograms

Main program - the main program serves as a monitor for the execution of the model options and prints solution.

READIN - this subroutine reads input data, preforms preliminary calculations and performs minor error checks.

READOU - this subroutine produces the evaluation reports.

REQMTS - calculates adjusted right side value on constraints to account for recruiter and/or canvassers.

START - calculates the initial value of Lagrange Multiplier for setting Search Interval end points.

PARTSL - calculates canvasser partial solution.

SEARCH - performs general fibonacci minimum search.

FVAL - function of Newton method to solve iteratively for recruiters or canvassers.

SOLN - subroutine that determines final solution using the Newton method as in the function FVAL.

ENLST2 - subroutine that calculates enlistments by cohort group

B.3 MERGE/BMD Time Series Regression Model

Resource requirements

Average run time - minimum 8 CPU seconds

Core required

MERGE 20K words

BMD 39K words

Input cards - including time-series data usually 200-600

Output pages - minimum 16 pages

Subprograms

MERGE

Main program - reads all input data, BMD controls cards, and MERGE control cards. Performs syntax check on all control cards.

CREATE - creates all new user defined variables.

MONTH - sets up alph name abbreviation of months for use by BMD reports.

NOTE - write output message.

FILES - reads time series data check into core.

IDENT - verifies that all variables to be used in regression exist.

PACK - left justifies name and removes embedded blanks.

FILE50 - creates edited control card file for input to BMD.

LISTRP - lists time series data.

BMD

Main program - the main program reads control cards, checks syntax, and performs calculations for the basic statistics (mean, standard deviations, correlations)

function AF - orders array elements by index pairs.

subroutine AOUT - prints correlation or variance matrices.

subroutine CHECK - checks sign of coefficients.

subroutine RDLBL2 - reads in labels cards.

subroutine TRANGN - variable transgeneration program.

function CALUIN - zero divide.

function LSHIFT - set character values.

subroutine RESIDS - performs residual analysis and plotting.

subroutine STEP - enter variable into regression.

subroutine STEPRG - performs stepwise regression.

subroutine REGRPT - prints stepwise regression report.

subroutine SENSE - evaluates sensitivity of coefficients for ridge regession and prints report.

subroutine MULSEA - computes the multiplicative seasonals, and prints seasonal report.

subroutine REPRT2 - report produced when fixed elasticities are indicated.

subroutine REPORT - summarizes the end results for each regression run.

subroutine MOVECH - moves characters from a character string to a second character string.

function COMP - word comparison.

APPENDIX C

THE HISTORICAL ACCESSION FILE

The Historical Accession File was developed from USAREC accession data for FY74 and FY75. The file contains the fraction of total accessions accounted for by each of the supply-limited cohorts under consideration, as depicted in Figure C.1 on the following page.

Table C.1 displays the current definition of items in the sort-field.

Table C.1

Entity	Columns	Definition
DRC	1-2	DRC identifier
DRC IND	6-7	Sequential DRC index (1-64)
REGION	10	Sequential region index (1-5)
ENL OPT	11	Enlistment option coded 1 = combat arms 2 = non-combat arms
TERM SER	12	Term of service coded 1 = 3-year term 2 = 4-year term or more
Cohort Group 1	13-17	Proportion of enlistments in first cohort group.
2	18-22	
3	23-27	
4	28-32	
5	33-37	
6	38-42	
7	43-47	
8	48-52	
Filler	53-57	
TOTAL ACCESSIONS	58-67	

								FRACTIONS OF ACCESSIONS BY COHORT									TOTAL ACCESSIONS	
DRC			DRC IND		REGION	ENL OPT	TERM SER	HSG BLACK 1-3A	HSG WHITE 1-3A	HSG BLACK 3B-4	HSG WHITE 3B-4	NHSG BLACK 1-3A	NHSG WHITE 1-3A	NHSG BLACK 3B-4	NHSG WHITE 3B-4			

Fig. C.1 —Historical Accession File Layout

APPENDIX D

ANNOTATED LISTING OF THE OPTIMAL RECRUITER ALLOCATION MODEL

ANNOTATION

SUBROUTINE STATEMENT NUMBER	ROUTINE: CONTRL
	This is the central control unit for the ORAM
14	The call to READIN reads all the input data and switches for the problem.
15	READOU(0) gives a full evaluation of the initial recruiter/canvasser allocation.
16	If IPUN $\neq$ 1 then only an evaluation of a particular allocation is made—otherwise a full set of optimizations is made.
19	ISWITCH = 2 for recruiter and canvasser model set upper limit for canvassers.
20,21	Set constraint limits and adjust coefficients according to constraint no. M7.
22	Calculate guess for Lagrange multiplier w
24	Branch to 250 for recruiter only.
25,26,27	Calculate initial guess for canvasser multiplier; set end points for Fibonacci Search.
28,29	Search and find candidate value of multiplier for canvassers.
31,32	Find tentative solutions for canvassers; adjust right side constraint value for recruiters.
33	Calculate candidate multiplier value for recruiters.
37	If canvassers achieve more than total accession requirements recalculate recruiter solution.
38,39,40,41	Calculate candidate value for multiplier test.
42	Calculate canvasser test multiplier for final decision.
44,45	For positive canvasser multiplier set associated value of recruiter multiplier
46	Canvasser multiplier set to zero.
47-51	Set final recruiter multiplier.
52	Generate solutions for recruiters if ISWITCH = 1 or recruiters and canvassers if ISWITCH = 2.
53	Loop end for all constraints.
54,55	Write out full set of solutions.
56-59	Write out matrix for recruiter solutions only; not intended to be a report as such.

```
      PROGRAM CONTRL(INPUT,OUTPUT,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7=P
     1UNCH)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/CALCCM/I(7,4),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/PERCEN/PCT(65,8),PCTTM(65,8,3),PPCTCA(65,3,2)
      COMMON/DRCNM/NMDRC(65)
      COMMON/CONSTR/I1,I2,I3,I4,I5,ISWTCH,IREGSW
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/RESULT/XREC(65,15),XCAN(65,15),REC0(65),CAN0(65),RLAGRG(50)
     1,CLAGRG(50)
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/OUT2/IRUN
      CALL READIN
      CALL READOU(C)
      IF( IRUN.NE.1 ) CALL EXIT
      DO 1000 MT=1,I5
      IF( ( ISWTCH.NE.1 ) .AND. ( MT.EQ.2 ) ) GO TO 1000
      IF( ISWTCH.NE.1 ) CALL REQMTS(2,1)
      CALL REQMTS(MT,1)
      CALL REQMTS(MT,2)
      IF(ISWTCH.EQ.1) CALL STARTR(WW)
C ***  BRANCH IF RECRUITERS ARE THE ONLY VARIABLES ***
      IF(ISWTCH.EQ.1) GO TO 250
      CALL STARTC(VV)
      TL = VV / 10.
      TU = 10. * VV
      CALL SEARCH(TL,TU,1.E-2,1.0,FFVAL,TTA,1,MT)
      VV = TTA
C *** CALCULATE CURRENT CANVASSER PARTIAL SOLUTION ***
      CALL PARTSL(VV)
      CALL REQMTS(MT,1)
      CALL STARTR(WW)
C *** CURRENT CANVASSER LEVEL DETERMINES RIGHT SIDE LIMITS ON RECRUITERS  **


      IF(RSIDER(MT).LE.0.0) GO TO 250
      TU = 10.  * WW
      TL = WW / 10.
      CALL SEARCH(TL,TU,1.E-2,1.0,FFVAL,TTA,2,MT)
      WW = TTA
      CLAGRG(MT) = VV * RECCST / WW - CANCST
C ** TEST FOR NON-NEGATIVITY OF CANVASSER LAGRANGE MULTIPLIER   ***
      IF(CLAGRG(MT).GT.0.0)RLAGRG(MT) = RECCST / WW
      IF(CLAGRG(MT).GT.0.0) GO TO 500
  250 CLAGRG(MT) = 0.
      WW = RECCST / WW
      TL = WW / 10.
      TU = 10. * WW
      CALL SEARCH(TL,TU,1.E-2,1.0,FFVAL,TTA,3,MT)
      RLAGRG(MT) = TTA
  500 CALL SOLN(MT)
 1000 CONTINUE
      DO 4000 MC=1,I5
 4000 CALL READOU(MC)
      WRITE(6,1080)(I,I=1,I5)
 1080 FORMAT(1H1,3X,*SOLUTIONS*,10I11/)

      DO 2200 I=1,MAXSTA
 2200 WRITE(6,1085)NMDRC(I),I,REC0(I),(XREC(I,MT),MT=1,I5)
 1085 FORMAT(5X,A5,I2,10(1X,F10.1))
      CALL EXIT
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: ENLIST
	This subroutine calculates the enlistments by cohort type j at DRC i for a given number of recruiters and canvassers on station.
8,9	Reset recruiters to X(i) value.
10-12	Calculate enlistments due to recruiters.
14-18	Calculate additional enlistments due to canvassers if ISWTCH=2.

```
      SUBROUTINE ENLST2(MC)
      COMMON/RESULT/XREC(65,15),XCAN(65,15),RECO(65),CANO(65),RLAGRG(50)
     1,CLAGRG(50)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/PERCEN/PCT(65,8),PCTTM(65,8,3),PPCTCA(65,8,2)
      COMMON/REGION/IREGN(5),IBEGIN(5),IEND(5)
      COMMON/CONSTR/I1,I2,I3,I4,I5,ISWTCH,IREGSW
      COMMON/CALCON/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      MCC = MC - I4
      IF( MCC.EQ.1) GO TO 100
      DO 110 I=1,MAXSTA
      REC(I) = XREC(I,MC)
      IF( MC.EQ.0 ) REC(I) = RECO(I)
      DO 110 J=1,JTYPES
  110 ENL(I,J) = C(I,J) * REC(I)**E(6,J)
      GO TO 115
  100 DO 20 L=1,NOREGN
      LL = L - 1
      IBB = IBEGIN(L)
      IEE = IEND(L)
      DO 15 I=IBB,IEE
      REC(I) = XREC(I,MC+LL)
      IF( MC.EQ.0 ) REC(I) = RECO(I)
      DO 15 J=1,JTYPES
   15 ENL(I,J) = C(I,J) * REC(I) ** E(6,J)
   20 CONTINUE
  115 IF( ISWTCH.NE.2 ) GO TO 150
      IF( MCC.EQ.1) GO TO 29
      DO 120 I=1,MAXSTA
      CAN(I) = XCAN(I,MC)
      IF( MC.EQ.0 ) CAN(I) = CANO(I)
      DO 120 J=1,JTYPES
  120 ENL(I,J) = ENL(I,J) + C(I,J) * CAN(I) ** E(7,J)
      GO TO 150
   29 DO 40 L=1,NOREGN
      LL = L - 1
      IBB = IBEGIN(L)
      IEE = IEND(L)
      DO 30 I=IBB,IEE
      CAN(I) = XCAN(I,MC+LL)
      IF( MC.EQ.0 ) CAN(I) = CANO(I)
      DO 30 J=1,JTYPES
   30 ENL(I,J) = ENL(I,J) + C(I,J) * CAN(I) ** E(7,J)
   40 CONTINUE
  150 RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3 ENLST2

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: FVAL1
	This subroutine is used only when canvassers are in the model. For specified values of VV and a given constraint index MT the associated canvasser solution is calculated. The sequence of VV values assigned by the Fibonacci search is such that convergence to the requirement specified by RSIDEC (MT) occurs.
30	Error message if fail to converge.

```
      FUNCTION FVAL1(VV,MT)
      COMMON/CALCOM/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/SETS/S(65,8)
C *** NEWTON METHOD TO SOLVE ITERATIVELY FOR RECRUITERS - GIVEN LAGRANGE
C *** MULTIPLIER FLAMDA ***
      EPSI = 1.E-3
      SUM = 0.
      XL0 = 1.
      DO 40 I=IB,IE
    5 XL = XL0
      DO 20 L=1,60
      SUM1 = 0.0
      SUM2 = 0.0
      DO 10 J=1,JTYPES
      TERM = E(7,J)*S(I,J)*XL**(E(7,J)-1.)
      SUM1 = SUM1 + TERM
   10 SUM2 = SUM2 + (E(7,J) - 1.) * TERM / XL
      IF(SUM2.EQ.0.) XLL = EPSI
      IF(SUM2.EQ.0.) GO TO 25
      XLL = XL - ( SUM1 -    VV    ) / SUM2
      IF(XLL.LT.0.) XL0 = XL0 / 2.
      IF(XLL.LT.0.) GO TO 5
      TOL = ABS( XLL - XL)
      IF(TOL.LT.EPSI ) GO TO 25
   20 XL = XLL
      WRITE(6,52)I,XLL,XL,VV
   52 FORMAT(//10X,*ERROR MESSAGE - FAILURE TO CONVERGE IN FVAL1 I= *,
     1I3,* VALUE 1 = *,E10.5,* VALUE 2 = *,E10.5/20X,*LAMDA = *,E10.5)
      CALL EXIT
   25 SUM = SUM + XLL
   40 CONTINUE
      FVAL1 = ABS(SUM - RSIDEC(MT))
      RETURN
      END
```

CARD NR.	SEVERITY	DETAILS	DIAGNOSIS OF PROBLEM
31	I	28 CD 32	FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT C
31	I	43 CD 32	FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT C
31	I	69 CD 32	FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT C

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
4 FVAL1

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: FVAL2
	This subroutine is used only when canvassers are in the model. For every value of WW assigned by the Fibonacci Search the corresponding number of recruiters associated with constraint (MT) is evaluated. Successive values WW assigned by the search will be such that the return gained by the recruiters will converge to the adjusted right side RSIDER (MT)
30	Error message if fail to converge

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```
      FUNCTION FVAL2(WW,MT)
      COMMON/CALCOM/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/SETR/B(65,8)
C *** NEWTON METHOD TO SOLVE ITERATIVELY FOR RECRUITERS - GIVEN LAGRANGE
C *** MULTIPLIER FLAMDA ***
      EPSI = 1.E-3
      SUM = 0.
      XLO = 10.
      DO 40 I=IB,IE
    5 XL = XLO
      DO 20 L=1,60
      SUM1 = 0.0
      SUM2 = 0.0
      DO 10 J=1,JTYPES
      TERM = E(6,J)*B(I,J)*XL**(E(6,J)-1.)
      SUM1 = SUM1 + TERM
   10 SUM2 = SUM2 + (E(6,J) - 1.) * TERM / XL
      IF(SUM2.EQ.0.) XLL = EPSI
      IF(SUM2.EQ.0.) GO TO 25
      XLL = XL - ( SUM1 -    WW    ) / SUM2
      IF(XLL.LT.0.) XLO = XLO / 2.
      IF(XLL.LT.0.) GO TO 5
      TOL = ABS( XLL - XL)
      IF(TOL.LT.EPSI ) GO TO 25
   20 XL = XLL
      WRITE(6,52)I,XLL,XL,FLAMDA
   52 FORMAT(//10X,*ERROR MESSAGE - FAILURE TO CONVERGE IN FVAL2 I= *,
     1I3,* VALUE 1 = *,E10.5,* VALUE 2 = *,E10.5/20X,*LAMDA = *,E10.5)
      CALL EXIT
   25 DO 30 J=1,JTYPES
      TERM = B(I,J) * XLL ** E(6,J)
   30 SUM = SUM + TERM
   40 CONTINUE
      FVAL2 = ABS(SUM - RSIDER(MT))
      RETURN
      END
```

```
CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   31       I      28 CD 32   FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT DES
   31       I      48 CD 32   FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT DES
   31       I      69 CD 32   FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT DES
```

SYMBOLIC REFERENCE MAP (R=1)

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: FVAL3
	This subroutine uses the Newton Method to solve iteratively for recruiters.

```
      FUNCTION FVAL3(FLAMDA,MT)
      COMMON/CALCOM/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,ITERMS,NOREGN
      COMMON/COST/FIXCST,RECOST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/CONSTR/I1,I2,I3,I4,I5,ISWTCH,IREGSW
      COMMON/SETD/B(65,8)
C *** NEWTON METHOD TO SOLVE ITERATIVELY FOR RECRUITERS - GIVEN LAGRANGE
C *** MULTIPLIER FLAMDA ***
      EPSI = 1.E-3
      SUM = 0.
      XLO = 10.
      VAL = RECOST / FLAMDA
      LSET = 0
    4 IF(LSET.EQ.1) XLO = 1.0
      IF(LSET.EQ.1) VAL = CANCST / FLAMDA
      K = 6 + LSET
      DO 40 I=IB,IE
    5 XL = XLO
      DO 20 L=1,60
      SUM1 = 0.0
      SUM2 = 0.0
      DO 10 J=1,JTYPES
      TERM = E(K,J)*B(I,J)*XL**(E(K,J)-1.)
      SUM1 = SUM1 + TERM
   10 SUM2 = SUM2 + (E(K,J) - 1.) * TERM / XL
      IF(SUM2.EQ.0.) XLL = EPSI
      IF(SUM2.EQ.0.) GO TO 25
      XLL = XL - ( SUM1 -  VAL   ) / SUM2
      IF(XLL.LT.0.) XLO = XLO / 2.
      IF(XLL.LT.0.) GO TO 5
      TOL = ABS( XLL - XL)
      IF(TOL.LT.EPSI ) GO TO 25
   20 XL = XLL
      WRITE(6,52)I,XLL,XL,FLAMDA
   52 FORMAT(//10X,*ERROR MESSAGE - FAILURE TO CONVERGE IN FVAL3 I= *,
     1I3,* VALUE 1 = *,E10.5,* VALUE 2 = *,E10.5/20X,*LAMDA = *,E10.5)
      CALL EXIT
   25 DO 30 J=1,JTYPES
      TERM = B(I,J) * XLL ** E(K,J)
   30 SUM = SUM + TERM
   40 CONTINUE
      IF( ISWTCH .EQ. 1 ) GO TO 50
      IF(LSET.EQ.1) GO TO 50
      LSET = 1
      GO TO 4
   50 FVAL3 = ABS( SUM - RSIDE(MT))
      RETURN
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: PARTSL
	This subroutine calculates intermediate solutions for canvasser variables.

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```
      SUBROUTINE PARTSL(VV)
C ** CALCULATES INTERMEDIATE SOLUTIONS FOR CANVASSER VARIABLES ***
      COMMON/CALCON/E(7,8),G(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGPM(50),RSIDER(50),RSIDEC(50)
      COMMON/SETB/B(65,8)
C *** MULTIPLIER FLAMDA ***
      EPSI = 1.E-3
      SUM = 0.
      XLO = 10.
      DO 40 I=IB,IE
    5 XL = XLO
      DO 20 L=1,60
      SUM1 = 0.0
      SUM2 = 0.0
      DO 10 J=1,JTYPES
      TERM = E(7,J)*G(I,J)*XL**(E(7,J)-1.)
      SUM1 = SUM1 + TERM
   10 SUM2 = SUM2 + (E(7,J) - 1.) * TERM / XL
      IF(SUM2.EQ.0.) XLL = EPSI
      IF(SUM2.EQ.0.) GO TO 25
      XLL = XL - ( SUM1 -    VV    ) / SUM2
      IF(XLL.LT.0.) XLO = XLO / 2.
      IF(XLL.LT.0.) GO TO 5
      TOL = ABS( XLL - XL)
      IF(TOL.LT.EPSI ) GO TO 25
   20 XL = XLL
      WRITE(6,52)I,XLL,XL,FLAMDA
   52 FORMAT(//10X,*ERROR MESSAGE - FAILURE TO CONVERGE IN FVAL1 I= *,
     1I3,* VALUE 1 = *,E10.5,* VALUE 2 = *,E10.5/20X,*LAMDA = *,E10.5)
      CALL EXIT
   25 CAN(I) = XLL
   40 CONTINUE
      RETURN
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: READIN
	This subroutine reads the input and switch values for the ORAM
39,40	These values are default. Currently set for 5 different regions NOREGN. IREGSW≠1 was dropped when it was decided not to specialize by particular cohort type.
41-48	Initial environmental factors set to one in case they are raised to a power but not read in.
49	READ and write input cards.
51-53	Free title card. This title will appear on all reports Use it Wisely.
56	If IRUN=1 full optimization, otherwise evaluation of initial recruiter/canvasser placement only.
59	Set size on no. of DRCs, no. of supply limited type, no. different terms of service.

```
      SUBROUTINE READIN
      COMMON/SHARE2/X(130),N,M,MN,NP1,NM1
      COMMON/START/Q(65,8),W(65,8),U(65,8),AT(65,8),AD(65,8)
      COMMON/PERCEN/PCT(65,8),PCTTM(65,8,3),FPCTCA(65,8,2)
      COMMON/REGION/IREGN(5),IBEGIN(5),IEND(5)
      COMMON/CONSTR/I1,I2,I3,I4,I5,ISWTCH,IREGSW
      COMMON/COHORT/PCTNCA(65,8,3),PCTCA(65,8,3),              NCAPCT(65
     1,8),CAPCT(65,8),PCTSTA(65)
      COMMON/CALCON/E(7,3),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/SUPPLY/ SIGN(8)
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/ACCESS/ACCREC(65,4,15),ACCCAN(65,4,15)
      COMMON/RESULT/XREC(65,15),XCAN(65,15),REC0(65),CAN0(65),RLAGRG(50)
     1,CLAGRC(50)
      COMMON/PERCNT/ FRACTT(50),CANFRA(50)
      COMMON/DRCNM/NMDRC(65)
      COMMON/OUT/NCHORT(8),ITITLE(13)
      COMMON/OUT2/IRUN
      INTEGER INAME(11)
      DIMENSION VAL(8)
      DIMENSION CON(8)
      DIMENSION TOTEML(65)
      DIMENSION FREGN(10),FSEPV(5)
      REAL NCAPCT
      DIMENSION SIGNS(8)
      DATA SIGNS/1.,1.,-1.,-1.,-1.,-1.,-1.,-1./
      DATA INAME/5HEND  ,5HQME  ,5HWAGEA,5HUNEMP,5HATT  ,5HADV  ,5HRECR
     1,5HCANV ,5HCLAST,5HCONST,5HPCTVL/
C *** SPECIAL SWITCHES -- ISWTCH AND IREGSW ***
C ** IF ISWTCH EQ. 1   THEN MODEL IS FOR RECRUITERS ONLY  ***
C ** IF ISWTCH NOT EQ. 1 THEN RECRUITERS AND CANVASSERS ARE VARIABLES ***
C*** IF IREGSW EQ. 1 THEN REGIONAL CONSTRAINTS ARE FOR TOTALS ONLY ***
C*** IF IREGSW EQ. 2 THEN REGIONAL CONSTRAINTS ARE BY COHORT TYPE  ***
C*** IF IREGSW EQ. 3 THEN THERE ARE NO REGIONAL CONSTRAINTS  *****
C*** IF IREGSW NOT EQ. 1 THEN REGIONAL CONSTRAINTS ARE BY COHORT TYPES ***
      IREGSW = 1
      NOREGN = 5
C *** INITIALIZE ENVIRONMENTAL FACTORS    ***
      DO 31 I=1,65
      DO 31 J=1,8
      Q(I,J) = 1.
      U(I,J) = 1.
      W(I,J) = 1.
      AT(I,J) = 1.
   31 AD(I,J) = 1.
      WRITE(6,14)
   14 FORMAT(1H1//10(*-*),*INPUT CARDS AS RECEIVED*//)
      READ(5,28) ITITLE
   28 FORMAT(8A10/5A10)
      WRITE(6,29) ITITLE
   29 FORMAT(9X,8A10/9X,5A10)
    2 FORMAT(10I5)
      READ(5,2) IRUN
      WRITE(6,42) IRUN
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: READIN
64	ISWITCH=1 recruiters only, 2 recruiters and canvassers, ISWPCT=1 proportions by type set by historical percentages otherwise ISWPCT≠1 will accept coefficients individually by type. (The latter is generally not the case.)
67	FUNEMP is a factor (near 1 e.g., 1.5) which modifies the basic unemployment rates at which the x sectional analyses was made. FACTOR multiplies the coefficients for missing data—e.g., given 8 months of data for analysis multiply by 1.5 to get yearly total.
71	SUPLY is desired level of supply limited cohorts. CANTOT is total canvasser limit.
75	RECCST, CANCST relative recruiter and canvasser unit cost. Set to 1., 1. for best convergence where 1 may actuahly represent 1 unit of $25,000.
79	FSERV(k), fraction of total supply with form of service type k.
86	Fraction of total supply in combat arms.
89	Fraction of total supply in region k.
94,95	Set indexes for loops later on.
96	Fixed cost is set to zero since it does not influence the optimization.
97	Initial counter (for what I am not sure).
98,99	Initialize counters for no. of DRCs in each region.

```
 42 FORMAT(//5X, 7HIRUN = ,I2)
    READ(5,2) MAXSTA,JTYPES,KTERMS
    WRITE(6,43)MAXSTA,JTYPES,KTERMS
 43 FORMAT(//5X,12HNO. DRC,S = , I3,3X,27HNO. SUPPLY LIMITED TYPES = ,
   1 I3,3X,27HNO. OF DIFF. TERMS OF SERVICE = ,I3)
  4 FORMAT(8F10.0)
    READ(5,4) ISWICH,ISWPCT
 51 FORMAT(//5X, 9HISWICH = ,I2,3X, 9HISWPCT = ,I2)
    WRITE(6,51)ISWICH,ISWPCT
    READ(5,4) FUNEMP,FACTOR
 47 FORMAT(//5X,37HUNEMPLOYMENT FACTOR REL. BASE CASE = ,F8.5,5X,26HFA
   1CTOR FOR MISSING DATA = ,F5.3)
    WRITE(6,47)FUNEMP,FACTOR
    READ(5,4) SUPLY ,CANTOT
 64 FORMAT(//5X,15HTOTAL SUPPLY = ,F10.0,5X,19HTOTAL CANVASSERS = ,F10
   1.0)
    WRITE(6,64) SUPLY ,CANTOT
    READ(5,4) RECOST,CANCST
 46 FORMAT(//5X,25HRECRUITER COST FACTOR  = ,F7.1,10X,24HCANVASSER COS
   1T FACTOR = ,F7.1)
    WRITE(6,46)RECOST,CANCST
    READ(5,4) (FSERV(K),K=1,KTERMS)
    WRITE(6,48)
 48 FORMAT(//5X,54HFRACTION OF SUPPLY LIMITED WITH TERM OF SERVICE TYP
   1E K)
    DO 81 K=1,KTERMS
 81 WRITE(6,57)K,FSERV(K)
 57 FORMAT(40X,I2,2X,F5.4)
    READ(5,4) FCOMBT
    WRITE(6,49)FCOMBT
 49 FORMAT(//5X,44HFRACTION OF SUPPLY LIMITED IN COMBAT ARMS = ,F7.4)
    READ(5,4) (FREGN(K),K=1,NOREGN)
    WRITE(6,52)
 52 FORMAT(//5X,49HFRACTION OF SUPPLY LIMITED IN REGION INDEXED BY K)
    DO 84 K=1,NOREGN
 84 WRITE(6,57)K,FREGN(K)
    IBIG = MAXSTA + 1
    KTTCA = 2.* KTERMS
    FIXSCT = 0.
    NCOUNT = 0
    DO 9 I=1,NOREGN
  9 IREGN(I) = 0
    DO 500 LL=1,11
    READ(5,10)  KWORD,I2,I1,(VAL(I),I=1,JTYPES)
    IF(EOF(5))1000,15
 10 FORMAT(A5,I2,2X,I1,8F8.0)
 12 FORMAT( 9X,A5,I2,2X,I1,3(2X,F11.5))
 15 WRITE(6,12) KWORD,I2,I1,(VAL(I),I=1,JTYPES)
    IF(KWORD.EQ.5HPCTVL) GO TO 400
    DO 20 I=1,10
    IVAL = 0
    IF(KWORD.EQ.INAME(I)) IVAL = I
    IF(KWORD.EQ.INAME(I))GO TO 25
 20 CONTINUE
    IF(IVAL.EQ.0) WRITE(6,21)
    IF(IVAL.EQ.0)CALL EXIT
 21 FORMAT(//10X,10(*-*),*UNRECOGNIZED NAME CARD - EXIT*)
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: READIN
100-175	Basic input loop. Everything entering here should be preceded by a name card listed in DATA INAME. A card with the word END cols 1 to 3 should end each data section in this loop. There is no total counter check within each section of data so that for example if the user states he has 63 DRCs then he must have the appropriate information for all DRCs. Format 10 is the primary form in which the data is read. Currently some values of the environmental factors are the same for all cohort types. This may change later hence right side VAL(1) could be changed to VAL(J) 123, 126,...,139.
150	The key word PCTVL sets up the branch to 400 which reads in the historical profile information.
153,154	FORMAT 401 is fundamental to the historical data. The three indexes IR, ICA, and ISER identify the region, combat, noncombat arms and type of term of service, FVAL is the total supply enlistments by DRC (it is not used in the calculations) VAL (J)'s represent the discrete breakout by DRC, by term of service, and combat and noncombat arms.
157	Exit from historical data input section.
158-160	First card for each DRC establishes name and tallies on region counter.
162-169	Combat arms and noncombat arms are separated within term of service.

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```
       25 IF(KWORD.EQ.5HEND  ) GO TO 500
          II = IVAL - 1
          NCOUNT = NCOUNT + 1
       27 READ(5,10)KWORD,I2,I1,(VAL(I),I=1,JTYPES)
          WRITE(6,12) KWORD,I2,I1,(VAL(I),I=1,JTYPES)
          IF(KWORD.EQ.5HEND  ) GO TO 500
       30 GO TO (110,120,130,140,150,160,170,180,190),II
      110 DO 111 J=1,JTYPES
      111  Q(I2,J) = VAL(1)
          GO TO 27
      120 DO 121 J=1,JTYPES
      121  W(I2,J) = VAL(1)
          GO TO 27
      130 DO 131 J=1,JTYPES
      131  U(I2,J) = VAL(1)
          GO TO 27
      140 DO 141 J=1,JTYPES
      141 AT(I2,J) = VAL(1)
          GO TO 27
      150 DO 151 J=1,JTYPES
      151 AD(I2,J) = VAL(1)
          GO TO 27
      160 REC(I2) = VAL(1)
          GO TO 27
      170 CAN(I2) = VAL(1)
          GO TO 27
C *** ELASTICITIES ***
      180 DO 181 J=1,JTYPES
      181  E(I2,J) = VAL(J)
          GO TO 27
C *** CONSTANTS FROM X SECTIONAL ANALYSIS ***
      190 DO 191 J=1,JTYPES
      191 CON(J) = VAL(J)
          GO TO 27
C *** PERCENTAGES TO BE CODED ***
      400 CONTINUE
          DO 415 I=1,IBIG
          DO 410 II=1,KTTCA
          READ(5,401)KWORD,ISTA,IR,ICA,ISER,(VAL(J),J=1,8),FVAL
      401 FORMAT(A5,   I2,2X,3I1,   8F5.4,5X,F10.1)
          WRITE(6,402)KWORD,ISTA,IR,ICA,ISER,(VAL(J),J=1,8),FVAL
      402 FORMAT(10X,A5,2X,I2,2X,3(I1,2X),8(2X,F6.4),5X,F10.1)
          IF(KWORD.EQ.5HEND  ) GO TO 500
          IF(II.EQ.1) IREGN(IR) = IREGN(IR) + 1
          IF( II.EQ.1 ) TOTENL(I) = FACTOR * FVAL
          IF(II.EQ.1) NMCRC(I) = KWORD
          IF(ICA.EQ.1) GO TO 408
          DO 405 J=1,8
C *** CHANGE STATION INDEX LATTER ***
      405 PCTNCA(I,J,ISER) = VAL(J)
          GO TO 410
      408 DO 409 J=1,8
      409 PCTCA(I,J,ISER) = VAL(J)
      410 CONTINUE
      415 CONTINUE
          WRITE(6,416)
      416 FORMAT(10X,10(*-*),* NO END CARD ENCOUNTERED AFTER PERCENT COHORT
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: READIN
173	Error exit if illegitimate card name appears on list.
177-186	Separate fraction by term of service for each category type J and each DRC I.
187-203	Define percents of cohort type J for each DRC I.
204-212	Normalize fractions for cohort type J at DRC I so that computerwise they sum to 1.
213-216	Write out total fraction (should be near 1) before correction as well as corrected fractions.
217-221	Renormalize total fractions.
222-231	Calculate C(I,J) coefficients for supply functions from environmental factor values and ISWPCT switch. Also calculate enlistments based on input values of recruiters and canvassers. The values of the x sectional parameters play an important role here.

```
     1DATA - EXIT*)
      CALL EXIT
      GO TO 500
  500 CONTINUE
 1000 CONTINUE
      DO 1016 I=1,MAXSTA
      DO 1016 J=1,8
      SUM = 0.
      DO 1010 K=1,KTERMS
      PCTTM(I,J,K) = PCTNCA(I,J,K) + PCTCA(I,J,K)
 1010 SUM = SUM + PCTTM(I,J,K)
      IF( SUM.EQ.0.0 ) GO TO 1016
      DO 1015 K=1,KTERMS
 1015 PCTTM(I,J,K) = PCTTM(I,J,K) / SUM
 1016 CONTINUE
      DO 1020 I=1,MAXSTA
      DO 1020 J=1,8
      SUM1 = 0.
      SUM2 = 0.
      DO 1018 K=1,KTERMS
      SUM1 = SUM1 + PCTCA(I,J,K)
 1018 SUM2 = SUM2 + PCTNCA(I,J,K)
      CAPCT(I,J) = SUM1
      NCAPCT(I,J) = SUM2
      TERM = SUM1 + SUM2
      IF(TERM)1017,1017,1019
 1017 PPCTCA(I,J,1) = 0.0
      PPCTCA(I,J,2) = 0.0
      GO TO 1020
 1019 PPCTCA(I,J,1) = SUM1 / TERM
      PPCTCA(I,J,2) = SUM2 / TERM
 1020 PCT(I,J) = CAPCT(I,J) + NCAPCT(I,J)
      DO 1030 I=1,MAXSTA
      SUM = 0.
      DO 1025 J=1,8
 1025 SUM = SUM + PCT(I,J)
 1030 PCTSTA(I) = SUM
      DO 1032 I=1,MAXSTA
      DO 1031 J=1,8
 1031 PCT(I,J) = PCT(I,J) / PCTSTA(I)
 1032 CONTINUE
      DO 1040 I = 1,MAXSTA
      WRITE(6,1041) I,PCTSTA(I),(PCT(I,J),J=1,8)
 1041 FORMAT(10X,I2,5X,9(2X,F6.4))
 1040 CONTINUE
      DO 1050 I=1,MAXSTA
      PCTSTA(I) = 0.0
      DO 1049 J=1,JTYPES
 1049 PCTSTA(I) = PCTSTA(I) + PCT(I,J)
 1050 CONTINUE
      DO 1100 J=1,JTYPES
      DO 1100 I=1,MAXSTA
C *** SPECIAL INPUT CHANGES UNTIL FURTHER NOTICE ***
      C(I,J) = C(I,J)**E(1,J)*W(I,J)**E(2,J)*(U(I,J)*FUNEMP)**E(3,J)*
     1AT(I,J)**E(4,J)*AD(I,J)**E(5,J)
      IF( ISWPCT.EQ.1 ) C(I,J) = C(I,J)*PCT(I,J) / PCTSTA(I)
      C(I,J) = C(I,J) * FACTOR * EXP(CON(J))
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: READIN
232-235	Write the values of the C (I,J) coefficients
236-244	Write the enlistments total and by cohort type for each DRC.
245-262	Set indexes for constraints and indexes for beginning and ending DRC's within each region.
263-265	Set RECO (I) to the initial input value. Set X (I).
266-270	Set initial value of canvassers CANO(s) to initial input value. Also set X (I) for canvassers.
271,272	Set signs (the instructions may currently be obsolete).
273,274	Initialize right side constraint values
275	Set right side (1)—the national goal to supply.
276,277	If canvassers are in the model right side (2) upper limit is CANTOT.
278-280	Set right side constraint values for term of service.
281	Set right side constraint value for combat arms.
282	IREGSW is set to one by default. At one time it was used to bypass regional constraints.
283-285	Set right side constraint values for regional requirements.
286-292	Write the values of the right side constraints. Set canvasser fractions.
293	Obsolete possibly.
294-296	Set canvasser regional fractions proportional to regional goals.
297-300	Initialize array of summary solutions as used by subroutine SOLN(MT) later.

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```
      ENL(I,J) = C(I,J) * REC(I)**E(6,J)
      IF( ISWTCH.NE.1 ) ENL(I,J) = ENL(I,J) +C(I,J) * CAN(I) **E(7,J)
 1100 CONTINUE
      WRITE(6,1547)
 1547 FORMAT(//10X,16HC(I,J),S BY TYPE)
      DO 1200 I=1,MAXSTA
 1200 WRITE(6,1210)I,(C(I,J),J=1,JTYPES)
 1210  FORMAT(10X,I5,9(1X,F10.2))
      WRITE(6,1211)
 1211 FORMAT(//3X,20(*-*),*ENLISTMENTS*,  20(*-*))
      DO 1220 I=1,MAXSTA
      SUM = 0.
      DO 1215 J=1,JTYPES
 1215 SUM = SUM + ENL(I,J)
      WRITE(6,1210) I,SUM,(ENL(I,J),J=1,JTYPES)
 1220 CONTINUE
C ** CONSTRAINT INDEXES ***
      I1 = 1
C *** CANVASSER CONSTRAINT - IF ANY ***
      I2 = I1 + 1
      IF(ISWTCH.EQ.1) I2 = I1
      I3 = I2 + KTERMS
      I4 = I3 + 1
      I5 = I4 + JTYPES * NOREGN
      IF(IREGSW.EQ.1) I5 = I4 + NOREGN
      IF(IREGSW.EQ.3) I5 = I4
      N = MAXSTA
      IF(ISWTCH.NE.1) N =    2 * N
      M = I5
      IBEGIN(1) = 1
      IEND(1) = IREGN(1)
      DO 1509 I=2,NOREGN
      IEND(I) = IEND(I-1) + IREGN(I)
 1509 IBEGIN(I) = IEND(I-1) + 1
      DO 1710 I=1,MAXSTA
      RECO(I) = REC(I)
 1710 X(I) = REC(I)
      IF(ISWTCH.NE.2) GO TO 1719
      DO 1712 I=1,MAXSTA
      CANO(I) = CAN(I)
      II = MAXSTA + I
 1712 X(II) = CAN(I)
 1719 DO 1720 J=1,JTYPES
 1720 SIGN(J) = SIGNS(J)
      DO 1800 I=1,50
 1800 RSIDE(I) = 0.
      RSIDE(1) = SUPLY
      IF(ISWTCH.EQ.1)GO TO 1805
      RSIDE(2) = CANTOT
 1805 DO 1810 K=1,KTERMS
      I = I2 + K
 1810 RSIDE(I) = FSERV(K) * RSIDE(1)
      RSIDE(I4) = FCCMBT * RSIDE(1)
      IF(IREGSW.NE.1) GO TO 1830
      DO 1820 K=1,NOREGN
      I = I4 + K
 1820 RSIDE(I) = FREGN(K) * RSIDE(1)

 1830 CONTINUE
      WRITE(6,1739)
 1739 FORMAT(5X,*RIGHT SIDE CONSTRAINT VALUES*)
      DO 1740 I=1,I5
      CANFRA(I) = 1.0
 1740 WRITE(6,1741)I,RSIDE(I)
 1741 FORMAT(10X,I5,5X,F10.1)
      ISET = 0
      I41 = I4 + 1
      DO 1930 I=I41,I5
 1930 CANFRA(I) = RSIDE(I) / RSIDE(1)
      DO 1940 I=1,MAXSTA
      DO 1940 MT=1,I5
      XCAN(I,MT) = 0.0
 1940 XREC(I,MT) = 0.0
   44 FORMAT(I2,1X,A5,2X,6F10.5)
      RETURN
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: READOU

This subroutine is the Report Generator.

```
      IF(K.EQ.2) WRITE(6,981)
      IF(K.EQ.1) IPRINT = 1
      IF(K.EQ.2) IPRINT = 2
  980 FORMAT( 50X,*TERM OF SERVICE - THREE YEARS*)
  981 FORMAT( 50X,*TERM OF SERVICE - FOUR OR MORE YEARS*)
C  *** OCCUPATIONAL SPECIALITY CONSTRAINTS ***
      IF(ISWTCH.EQ.1) WRITE(6,991)(J,J=1,JTYPES)
      IF(ISWTCH.NE.1) WRITE(6,995)(J,J=1,JTYPES)
      DO 215 LL=1,NOREGN
      RSUMR = 0.0
      RSUMC = 0.0
      RSUMA = 0.0
      LLL = LL
      IF(LL.GT.1) LLL = LL + 1
      WRITE(6,994) LLL
      IB = IBEGIN(LL)
      IE = IEND(LL)
      DO 202 J=1,JTYPES
  202 RSUMTP(J) = 0.0
      DO 210 I=IB,IE
      SUMA = 0.0
      SUMR = SUMR + REC(I)
      SUMC = SUMC + CAN(I)
      RSUMR = RSUMR + REC(I)
      RSUMC = RSUMC + CAN(I)
      DO 204 J=1,JTYPES
      TERTYP(J) = ENL(I,J) * PCTTM(I,J,K)
      SUMTYP(J) = SUMTYP(J) + TERTYP(J)
      SUMA = SUMA + TERTYP(J)
      RSUMTP(J) = RSUMTP(J) + TERTYP(J)
      RSUMA = RSUMA + TERTYP(J)
      SUM = SUM + TERTYP(J)
  204 CONTINUE
      IF(ISWTCH.EQ.1) WRITE(6,992) NMORC(I),I,REC(I)        ,SUMA,(TERTYP
     1(J),J=1,JTYPES)
      IF(ISWTCH.NE.1) WRITE(6,992) NMORC(I),I,REC(I),CAN(I),SUMA,(TERTYP
     1(J),J=1,JTYPES)
  210 CONTINUE
      IF(ISWTCH.EQ.1) WRITE(6,1075)RSUMR,RSUMA,(RSUMTP(J),J=1,JTYPES)
      IF(ISWTCH.NE.1) WRITE(6,1075)RSUMR,RSUMC,RSUMA,(RSUMTP(J),J=1,JTYP
     1ES)
      PRSUMR(LL) = RSUMR
      PRSUMA(LL) = RSUMA
      PRSUMC(LL) = RSUMC
      DO 214 J=1,JTYPES
  214 PSUMTP(LL,J) = RSUMTP(J)
  215 CONTINUE
      GO TO 1000
  300 L= MT - I3
      WRITE(6,11)
      IF( ISTRAT.EQ.0 ) WRITE(6,989) ITITLE
      IF(ISTRAT.EQ.1) WRITE(6,990) RSIDE(MC),ITITLE
      IF(ISTRAT.EQ.2) WRITE(6,290) RSIDE(MC),ITITLE
      IF(ISTRAT.EQ.3) WRITE(6,292) RSIDE(MC),ITITLE
      IF(ISTRAT.EQ.4) WRITE(6,390) RSIDE(MC),ITITLE
      IF(ISTRAT.EQ.5) WRITE(6,938) RSIDE(1) ,ITITLE
      IF(L.EQ.1) WRITE(6,982)
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```
                IF(L.EQ.2) WRITE(6,983)
                IF(L.EQ.1) IPRINT = 3
            982 FORMAT( 50X,*OCCUPATIONAL SPECIALITY - COMBAT ARMS*)
            983 FORMAT( 50X,*OCCUPATIONAL SPECIALITY - NON-COMBAT ARMS*)
                IF(ISWTCH.EQ.1) WRITE(6,991)(J,J=1,JTYPES)
                IF(ISWTCH.NE.1) WRITE(6,995)(J,J=1,JTYPES)
                DO 315 LL=1,NUREGN
                RSUMR = 0.0
                RSUMC = 0.0
                RSUMA = 0.0
                DO 302 J=1,JTYPES
            302 RSUMTP(J) = 0.0
                LLL = LL
                IF(LL.GT.1) LLL = LL + 1
                WRITE(6,984) LLL
                IB = IBEGIN(LL)
                IE = IEND(LL)
                DO 310 I=IB,IE
                SUMA = 0.0
                SUMR = SUMR + REC(I)
                SUMC = SUMC + CAN(I)
                RSUMR = RSUMR + REC(I)
                RSUMC = RSUMC + CAN(I)
                DO 304 J=1,JTYPES
                TERTYP(J) = INL(I,J) * PPCTCA(I,J,L)
                SUMTYP(J) = SUMTYP(J) + TERTYP(J)
                RSUMTP(J) = RSUMTP(J) + TERTYP(J)
                SUMA = SUMA + TERTYP(J)
                RSUMA = RSUMA + TERTYP(J)
                SUM = SUM + TERTYP(J)
            304 CONTINUE
                IF(ISWTCH.EQ.1) WRITE(6,992) NMORC(I),I,REC(I)        ,SUMA,(TERTYP
               1(J),J=1,JTYPES)
                IF(ISWTCH.NE.1) WRITE(6,992) NMORC(I),I,REC(I),CAN(I),SUMA,(TERTYP
               1(J),J=1,JTYPES)
            310 CONTINUE
                IF(ISWTCH.EQ.1) WRITE(6,1075)RSUMR,RSUMA,(RSUMTP(J),J=1,JTYPES)
                IF(ISWTCH.NE.1) WRITE(6,1075)RSUMR,RSUMC,RSUMA,(RSUMTP(J),J=1,JTYP
               1ES)
                PRSUMR(LL) = RSUMR
                PRSUMC(LL) = RSUMC
                PRSUMA(LL) = RSUMA
                DO 314 J=1,JTYPES
            314 PSUMTP(LL,J) = RSUMTP(J)
            315 CONTINUE
                GO TO 1000
          C *** REGIONAL QUALITY CONSTRAINTS ***
            400 MTT = MT - I4
                IF(MC.NE.MTT) GO TO 2030
                IF(IREGSW.EQ.1) GO TO 430
                MM = (MTT - 1 ) / JTYPES + 1
                MMM = MM
                IF(MM.GT.1) MMM = MM + 1
                IB = IBEGIN(MM)
                IE = IEND(MM)
                JTYPE = MTT - ( MM - 1 ) * JTYPES
                GO TO 900
```

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```
      430 IB=IREGIN(MTT)
          IE=IEND(MTT)
          MMM = MTT
          IF(MTT.GT.1) MMM = MTT + 1
          GO TO 900
    C *** ACCESSION CONSTRAINT ***
      900 CONTINUE
          WRITE(6,11)
          IF( ISTRAT.EQ.0 ) WRITE(6,989) ITITLE
          IF(ISTRAT.EQ.1) WRITE(6,990) RSIDE(MC),ITITLE
          IF(ISTRAT.EQ.2) WRITE(6,290) RSIDE(MC),ITITLE
          IF(ISTRAT.EQ.3) WRITE(6,292) RSIDE(MC),ITITLE
          IF(ISTRAT.EQ.4) WRITE(6,390) RSIDE(MC),ITITLE
          IF(ISTRAT.EQ.5) WRITE(6,998) RSIDE(1) ,ITITLE
      984 FORMAT(/59X,*REGION *,I2)
      990 FORMAT(1X ,130(*-*)/5X,*STRATEGY - MIN COST SUBJECT TO NATIONAL TO
         1TAL ACCESSION REQUIREMENT *,F10.0/1X,13A10/1X,130(*-*))
      998 FORMAT(1X ,130(*-*)/5X,*STRATEGY - MIN COST SUBJECT TO REGIONAL TO
         1TAL ACCESSION REQUIREMENT *,F10.0/1X,13A10/1X,130(*-*))
      390 FORMAT(1X ,130(*-*)/5X,*STRATEGY - MIN COST SUBJECT TO COMBAT ARMS
         1 REQUIREMENT *,F10.0/1X,13A10/1X,130(*-*))
      290 FORMAT(1X ,130(*-*)/5X,*STRATEGY - MIN COST SUBJECT TO 3 YR. TERM
         1OF SERVICE REQUIREMENT *,F10.0/1X,13A10/1X,130(*-*))
      292 FORMAT(1X ,130(*-*)/5X,*STRATEGY - MIN COST SUBJECT TO 4 YR.+ TERM
         1 OF SERVICE REQUIREMENT *,F10.0/1X,13A10/1X,130(*-*))
          IF(ISWTCH.EQ.1) WRITE(6,991)(J,J=1,JTYPES)
          IF(ISWTCH.NE.1) WRITE(6,995)(J,J=1,JTYPES)
      991 FORMAT(/5X,*DRC*,2X,*NO.*,2X,*NO. RECRUITERS*,3X,*NO. ACCESSIONS*,
         13X,*ACCESSIONS BY TYPE*/45X,4(*TYPE *,I1,3X))
          DO 916 LL=1,NOREGN
          RSUMR = 0.0
          RSUMC = 0.0
          RSUMA = 0.0
          DO 902 J=1,JTYPES
      902 RSUMTP(J) = 0.0
          LLL = LL
          IF(LL.GT.1) LLL = LL + 1
          WRITE(6,984) LLL
          IB = IREGIN(LL)
          IE = IEND(LL)
          DO 910 I=IB,IE
          SUMR = SUMR + REC(I)
          SUMC = SUMC + CAN(I)
          RSUMR = RSUMR + REC(I)
          RSUMC = RSUMC + CAN(I)
          SUMA = 0.0
          DO 904 J=1,JTYPES
          TERTYP(J) = ENL(I,J)
          SUMTYP(J) = SUMTYP(J) + TERTYP(J)
          RSUMTP(J) = RSUMTP(J) + TERTYP(J)
          SUMA = SUMA + TERTYP(J)
          RSUMA = RSUMA + TERTYP(J)
          SUM = SUM + TERTYP(J)
      904 CONTINUE
          IF(ISWTCH.EQ.1) WRITE(6,992) NMDRC(I),I,REC(I)        ,SUMA,(TERTYP
         1(J),J=1,JTYPES)
          IF(ISWTCH.NE.1) WRITE(6,992) NMDRC(I),I,REC(I),CAN(I),SUMA,(TERTYP
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     1(J),J=1,JTYPES)
 910 CONTINUE
     IF(ISWTCH.EQ.1) WRITE(6,1075)RSUMR,RSUMA,(RSUMTP(J),J=1,JTYPES)
     IF(ISWTCH.NE.1) WRITE(6,1075)RSUMR,RSUMC,RSUMA,(RSUMTP(J),J=1,JTYP
    1ES)
     PRSUMR(LL) = RSUMR
     PRSUMA(LL) = RSUMA
     PRSUMC(LL) = RSUMC
     DO 914 J=1,JTYPES
 914 PSUMTP(LL,J) = RSUMTP(J)
 915 CONTINUE
     GO TO 1000
 995 FORMAT(/5X,*DRC*,2X,*NO.*,2X,*NO. RECRUITERS*,3X,*NO. CANVASSERS*,
    12X,* NO. ACCESSIONS*,3X,*ACCESSIONS BY TYPE*/60X,4(*TYPE *,I1,3X))
 992 FORMAT(5X,A5,I2,8(2X,F10.1))
 989 FORMAT( 1X,130(*-*)/5X,*NO OPTIMIZATION STRATEGY - EVALUATION BASE
    1D ON INPUT VALUES OF RECRUITING FORCE*/1X,13A10/1X,130(*-*))
1000 CONTINUE
     IF(ISWTCH.EQ.1) WRITE(6,1050)SUMR,SUM,(SUMTYP(J),J=1,JTYPES)
     IF(ISWTCH.NE.1) WRITE(6,1050)SUMR,SUMC,SUM,(SUMTYP(J),J=1,JTYPES)
1050 FORMAT(2X,80(*-*)/9X,*TOTALS*,8(F10.1,2X))
1075 FORMAT(2X,80(*-*)/5X,*SUBTOTALS*,8(F10.1,2X))
     DO 1500 L=1,NOREGN
     PRSUMR(L) = 100. * PRSUMR(L) / SUMR
     PRSUMA(L) = 100. * PRSUMA(L) / SUM
     IF(SUMC.NE.0.0) PRSUMC(L) = 100. * PRSUMC(L) / SUMC
     DO 1495 J=1,JTYPES
     STP(J) = 0.0
1495 PSUMTP(L,J) = 100.0 * PSUMTP(L,J) / SUM
1500 CONTINUE
     WRITE(6,1600)
1600 FORMAT( /47X,10(*-*),*PERCENT SUMMARY TABLE*,10(*-*))
     IF( ISTRAT.EQ.0 ) WRITE(6,989) ITITLE
     IF(ISTRAT.EQ.1) WRITE(6,990) RSIDE(MC),ITITLE
     IF(ISTRAT.EQ.2) WRITE(6,290) RSIDE(MC),ITITLE
     IF(ISTRAT.EQ.3) WRITE(6,292) RSIDE(MC),ITITLE
     IF(ISTRAT.EQ.4) WRITE(6,390) RSIDE(MC),ITITLE
     IF(ISTRAT.EQ.5) WRITE(6,998) RSIDE(1) ,ITITLE
     IF(MT.EQ.I1) WRITE(6,1675)
     IF(IPRINT.EQ.1) WRITE(6,980)
     IF(IPRINT.EQ.2) WRITE(6,981)
     IF(IPRINT.EQ.3) WRITE(6,982)
1675 FORMAT( 50X,*TOTAL ACCESSIONS*)
     SA = 0.
     SC = 0.
     SP = 0.0
     IF(ISWTCH.EQ.1) WRITE(6,1660)(J,J=1,JTYPES)
     IF(ISWTCH.NE.1) WRITE(6,1670)(J,J=1,JTYPES)
1660 FORMAT(/17X,*RECRUITERS*,1X,*ACCESSIONS*,4X,7(*TYPE*,I2,6X))
1670 FORMAT(/17X,*RECRUITERS*,1X,*CANVASSERS*,1X,*ACCESSIONS*,4X,6(*TYP
    1E*,I2,6X))
     DO 1700 L=1,NOREGN
     LL = L
     IF(L.GT.1) LL=L + 1
     WRITE(6,984)LL
     IF(ISWTCH.EQ.1)WRITE(6,1075)PRSUMR(L),PRSUMA(L),(PSUMTP(L,J),J=1,
    1JTYPES)
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: REQMTS
	This subroutine performs two functions. If KT=1 the right side values for the recruiters and canvassers is modified when ISWITCH=1.
	If KT=2 then the coefficients C(I,J)'s and fractions for combat arms, terms of service are appropriately modified. Some right side modification is also made.
20,21	Set beginning and ending indexes.
22	Set sum total to zero initially.
23-27	Branch to appropriate class of constraints for given index MT.
28-30	Error exit for index out of range.
32-42	Evaluate total cost for recruiters and canvassers.
44-46	Readjust right side values for canvasser total and recruiters.
48-59	Modify right side or B(I,J)'s for term of service depending on whether K=1 or 2.

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```
      SUBROUTINE REQMTS(MT,KT)
      COMMON/SHARED/X(130),N,M,MN,NP1,NM1
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NORTGM
      COMMON/PERCTM/PCT(65,8),PCTTM(65,8,3),PPCTCA(65,8,2)
      COMMON/REGION/IREGN(5),IREGIN(5),IEND(5)
      COMMON/CONSTR/I1,I2,I3,I4,I5,ISWTCH,IREGSW
      COMMON/CALCOM/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SUPPLY/ SIGN(8)
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IS,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/SITB/B(65,8)
      COMMON/PERCNT/ FRACTT(50),CANFRA(50)
C *** SETS RIGHT SIDE VALUE IF KT = 1 - SETS BIJ,S IF KT = 2
C *** CALCULATES ADJUSTED RIGHT SIDE VALUE ON CONSTRAINTS TO ACOUNT FOR
C ** BOTH RECRUITERS AND CANVASSERS ***
      IF( (ISWTCH.EQ.1) .AND. (KT.EQ.1) ) RSIDER(MT)=RSIDE(MT)
      IF( (ISWTCH.EQ.1) .AND. (KT.EQ.1) ) RSIDEC(MT)= 0.
      IF( (ISWTCH.EQ.1) .AND. (KT.EQ.1) ) GO TO 1000
      IF(KT.EQ.2) IS=1
      IF(KT.EQ.2) IE=MAXSTA
      SUM = 0.
      IF(MT-I1)100,900,5
    5 IF(MT - I2)150,150,10
   10 IF(MT-I3)200,200,20
   20 IF(MT-I4)300,300,30
   30 IF(MT-I5)400,400,40
   40 WRITE(6,41)
   41 FORMAT(//9X,*INDEX ERROR IN RESTNT - EXIT*)
      CALL EXIT
C *** OBJECTIVE FUNCTION ***
  100 DO 110 I=1,MAXSTA
  110 SUM = SUM + REC(I)
      SUM = SUM * RECCST
      SUM = SUM + FIXCST
      IF(ISWTCH.EQ.1) GO TO 130
      SUM1 = 0.
      DO 120 I=1,MAXSTA
  120 SUM1 = SUM1 + CAN(I)
      SUM = SUM + CANCST * SUM1
  130 VAL = SUM
      GO TO 1000
C *** CANVASSER CONSTRAINT - IF ANY ***
  150 RSIDEC(MT) = RSIDE(2)
      RSIDER(MT) = RSIDE(MT) - SUM
      GO TO 1000
C *** TERM OF SERVICE CONSTRAINTS ***
  200 K= MT - I2
      GO TO(205,215),KT
  205 DO 210 I=1,MAXSTA
      DO 210 J=1,JTYPES
  210 SUM = SUM + PCTTM(I,J,K) * C(I,J) * CAN(I) ** E(7,J)
      RSIDEC(MT) = RSIDE(2)
      RSIDER(MT) = RSIDE(MT) - SUM
      GO TO 1000
  215 DO 220 I=1,MAXSTA
      DO 220 J=1,JTYPES
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: REQMTS
61-72	Modify right side B(I,J)'s for combat arms depending on whether KT=1 or 2
74	Set basic value of index.
75	IREGSW=1 by default
76-88	This branch is not intended for official use but is left in in case of future specialization to specific cohort type optimization.
86-88	B(I,J) transformation in proportion for regional constraints.
89,90	Set beginning and ending indexes for regional constraints.
91-102	Modify canvasser and recruiter constraint values or B(I,J)'s depending on KT=1 or 2.
104-114	Modify total accessions remaining requirements or set B(I,J)'s if KT=2.

```
  220 B(I,J) = POTTM(I,J,K) * C(I,J)
      GO TO 1000
C *** OCCUPATIONAL SPECIALITY CONSTRAINTS ***
  300 L = MT - I3
      GO TO(305,315),KT
  305 DO 310 I=1,MAXSTA
      DO 310 J=1,JTYPES
  310 SUM = SUM + PROTCA(I,J,L) * C(I,J) * CAN(I) ** E(7,J)
      RSIDEC(MT) = RSIDE(2)
      RSIDER(MT) = RSIDE(MT) - SUM
      GO TO 1000
  315 DO 320 I=1,MAXSTA
      DO 320 J=1,JTYPES
  320 B(I,J) = PROTCA(I,J,L) * C(I,J)
      GO TO 1000
C *** REGIONAL QUALITY CONSTRAINTS ***
  400 MTT = MT - I4
      IF(IRECRG.EQ.1) GO TO 430
      MM = ( MTT - 1 ) / JTYPES + 1
      IB = IBEGIN(MM)
      IE = IEND(MM)
      JTYPE = MTT - ( MM - 1 ) * JTYPES
      GO TO(405,415),KT
  405 DO 410 I=IB,IE
  410 SUM = SUM + C(I,JTYPE) * CAN(I) ** E(7,JTYPE)
      RSIDEC(MT) = RSIDE(2) * CANFRA(MT)
      RSIDER(MT) = RSIDE(MT) - SUM
      GO TO 1000
  415 DO 420 I=IB,IE
  420 B(I,JTYPE) = C(I,JTYPE)
      GO TO 1000
  430 IB=IBEGIN(MTT)
      IE=IEND(MTT)
      GO TO(435,455),KT
  435 DO 450 I=IB,IE
      DO 440 J=1,JTYPES
  440 SUM = SUM + C(I,J) * CAN(I) ** E(7,J)
  450 CONTINUE
      RSIDEC(MT) = RSIDE(2) * CANFRA(MT)
      RSIDER(MT) = RSIDE(MT) - SUM
      GO TO 1000
  455 DO 460 I=IB,IE
      DO 460 J=1,JTYPES
  460 B(I,J) = C(I,J)
      GO TO 1000
C *** ACCESSION CONSTRAINT ***
  900 GO TO(905,915),KT
  905 DO 910 J=1,JTYPES
      DO 910 I=1,MAXSTA
  910 SUM = SUM + C(I,J) * CAN(I) ** E(7,J)
      RSIDEC(MT) = RSIDE(2)
      RSIDER(MT) = RSIDE(MT) - SUM
      GO TO 1000
  915 DO 920 I=1,MAXSTA
      DO 920 J=1,JTYPES
  920 B(I,J) = C(I,J)
      GO TO 1000

 1000 RETURN
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: SEARCH
	This subroutine is mathematically the most efficient search minimization known. The search is made over interval TL,TU. Three different functions are called depending on the value of IFUN. The coefficients B(I,J) used in the functions FVAL1, FVAL2, FVAL3 are set by REQMTS (MT,KT)
8,9	Set the constants for the "golden section."
10-46	Switching of end points and function values over a contracting interval TL,TU which decreases by a factor .618...per iteration.
48,49	Error message if convergence criteria are not met within 60 iterations.

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```
      SUBROUTINE SEARCH(TL,TU,EPSLON,DELTA,FFVAL,TTA,IFUN,MT)
C**GENERAL FIBON. MIN. SEARCH OVER INTERVAL(TL,TU) WITH FUNCTION VALUES
C   AGREEING TO -LOG10(DELTA) PLACES AND ARGUEMENTS TO WITHIN -LOG10(EPSLON)
C   PLACES.   SOLUTION VALUE IS FFVAL AT MINIMIZING POINT TTA.  USER SUPPLIES
C   FUNCTION FVAL(ARGUEMENT)   ***
C *** THIS SEARCH IS USED TO EVALUATE THREE DIFFERENT MINIMUMS
C *** SET BY IFUN ***
      C2 = (SQRT(5.) - 1.) / 2.
      C1 = 1. - C2
      ISET = 3
      DO 100 L=1,60
      IF(ISET - 2)40,10,10
   10 TB = TL + C2 * ( TU - TL )
      GO TO (11,12,13),IFUN
   11 VALB=FVAL1(TB,MT)
      GO TO 30
   12 VALB=FVAL2(TB,MT)
      GO TO 30
   13 VALB=FVAL3(TB,MT)
   30 IF(ISET-2)40,60,40
   40 TA = TL + C1 * ( TU - TL )
      GO TO (41,42,43),IFUN
   41 VALA = FVAL1(TA,MT)
      GO TO 60
   42 VALA = FVAL2(TA,MT)
      GO TO 60
   43 VALA = FVAL3(TA,MT)
   60 IF(VALA- VALB - DELTA )65,65,80
   65 IF(VALA- VALB + DELTA )70,70,90
   70 TU = TB
      TB = TA
      VALB = VALA
      ISET = 1
      GO TO 100
   80 TL = TA
      TA = TB
      VALA = VALB
      ISET = 2
      GO TO 100
   90 TL = TA
      TU = TB
      IF(TU.EQ.0.) GO TO 95
      IF(ABS(TL/TU - 1.).LE.EPSLON) GO TO 150
   95 IF(TU.EQ.TL) GO TO 150
      ISET = 3
  100 CONTINUE
      WRITE(6,140)
  140 FORMAT( 10X, *SEARCH FAILED TO FIND MINIMUM AFTER 60 ITERATIONS*)
  150 TTA = ( TU + TL ) / 2.
      GO TO (151,152,153),IFUN
  151 FFVAL = FVAL1(TTA,MT)
      GO TO 200
  152 FFVAL = FVAL2(TTA,MT)
      GO TO 200
  153 FFVAL = FVAL3(TTA,MT)
  200 RETURN
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: SOLN
	This subroutine records all solutions and writes out solutions as they occur for each constraint or requirement MT

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```
      SUBROUTINE SOLN(MT)
      COMMON/CALCON/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/RESULT/XREC(65,15),XCAN(65,15),RECJ(65),CANJ(65),RLAGRG(50)
     1,CLAGRG(50)
      COMMON/ACCESS/ACCREC(65,4,15),ACCCAN(65,4,15)
      COMMON/SETB/B(65,8)
      COMMON/DRCNM/NMDRC(65)
      COMMON/CONSTR/I1,I2,I3,I4,I5,ISWTCH,IREGSW
C *** NEWTON METHOD TO SOLVE ITERATIVELY FOR RECRUITERS - GIVEN LAGRANGE
C *** MULTIPLIER FLAMDA ***
      EPSI = 1.E-3
      SUMR = 0.0
      SUMC = 0.0
      SUMAR= 0.0
      SUMAC= 0.0
      SUM = 0.
      VAL = RECCST / RLAGRG(MT)
      XL0 = 10.
      LSET = 0
    4 K = 6 + LSET
      IF(LSET.EQ.1) VAL = ( CANCST + CLAGRG(MT) )/ RLAGRG(MT)
      IF(LSET.EQ.1) XL0 = 1.0
      DO 40 I=IB,IE
    5 XL = XL0
      DO 20 L=1,60
      SUM1 = 0.0
      SUM2 = 0.0
      DO 10 J=1,JTYPES
      TERM = E(K,J) * B(I,J) * XL ** ( E(K,J) - 1.)
      SUM1 = SUM1 + TERM
   10 SUM2 = SUM2 + ( E(K,J)- 1.) * TERM / XL
      IF(SUM2.EQ.0.) XLL = EPSI
      IF(SUM2.EQ.0.) GO TO 25
      XLL = XL - ( SUM1 -  VAL    ) / SUM2
      IF(XLL.LT.0.) XL0 = XL0 / 2.
      IF(XLL.LT.0.) GO TO 5
      TOL = ABS( XLL - XL)
      IF(TOL.LT.EPSI ) GO TO 25
   20 XL = XLL
      WRITE(6,53)I,XLL,XL,FLAMDA
   53 FORMAT(//10X,*ERROR MESSAGE - FAILURE TO CONVERGE IN SOLN  I= *,
     1I3,* VALUE 1 = *,E10.5,* VALUE 2 = *,E10.5/20X,*LAMDA = *,E10.5)
      CALL EXIT
   25 IF(LSET)35,35,30
C ** CANVASSERS  ***
   30 XCAN(I,MT) = XLL
      SUMC = SUMC + XLL
      DO 32 J=1,JTYPES
      ACCCAN(I,J,MT) = B(I,J) * XLL ** E(7,J)
   32 SUMAC = SUMAC + ACCCAN(I,J,MT)
      GO TO 40
C *** RECRUITERS ***
   35 XREC(I,MT) = XLL
```

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```
      SUMR = SUMR + XLL
      DO 37 J=1,JTYPES
      ACCREC(I,J,MT) = B(I,J) * XLL ** E(6,J)
   37 SUMAR = SUMAR + ACCREC(I,J,MT)
   40 CONTINUE
      IF(ISWTCH.EQ.1) GO TO 50
      IF(LSET.EQ.1) GO TO 50
      LSET = 1
      GO TO 4
   50 WRITE(6,1)
    1 FORMAT(1H1)
      IF(ISWTCH.EQ.1) GO TO 70
      SUMACR = SUMAC + SUMAR
   52 FORMAT(/10X,*CONSTRAINT NO. *,I2,5X,*REQUIREMENT *,F10.1,5X,*TOTAL
     1 RECRUITERS *,F10.1/25X,*TOTAL CANVASSERS *,F10.1,5X,*ACCESSIONS *
     2,F10.1)
      WRITE(6,52)MT,RSIDE(MT),SUMR,SUMC,SUMACR
      DO 60 I=IB,IE
   60 WRITE(6,61)I,NMDRC(I),XREC(I,MT),XCAN(I,MT),(ACCREC(I,J,MT),J=1,JT
     1YPES),(ACCCAN(I,J,MT),J=1,JTYPES)
   61 FORMAT(5X,I2,2X,A5,8(2X,F10.1))
   70 IF(ISWTCH.NE.1) GO TO 100
      WRITE(6,62) MT,RSIDE(MT),SUMR,SUMAR
   62 FORMAT(/10X,*CONSTRAINT NO. *,I2,5X,*REQUIREMENT *,F10.1,5X,*TOTAL
     1 RECRUITERS *,F10.1,5X,*ACCESSIONS *,F10.1)
      DO 80 I=IB,IE
   80 WRITE(6,61)I,NMDRC(I), XREC(I,MT),(ACCREC(I,J,MT),J=1,JTYPES)
  100 RETURN
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: STARTC
	This subroutine is called only when canvassers are in the model. The VV value calculated is a guess at an initial value. It is used to set end points for the Fibonacci search.

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```
      SUBROUTINE STARTC(VV)
      COMMON/CALCON/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NOREGN
      COMMON/COST/FIXCST,RECCST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWMOD/IB,IE,ICOUNT,FLACRM(50),RSIDER(50),RSIDEC(50)
      COMMON/SETB/B(65,8)
C *** CALCULATES INITIAL VALUE OF LAGRANGE MULTIPLIER FOR SETTING SEARCH
C *** INTERVAL END POINTS ***
      SUM = 0.0
      DO 20 J=1,JTYPES
      SUM1 = 0.0
      DO 10 I=IB,IE
   10 SUM1 = SUM1 + B(I,J) * CAN(I) ** E(7,J)
   20 SUM = SUM + E(7,J) * SUM1
      SUM1 = 0.0
      DO 30 I=IB,IE
   30 SUM1 = SUM1 + CAN(I)
      VV = SUM / SUM1
      RETURN
      END
```

ANNOTATION

SUBROUTINE STATEMENT NUMBER	SUBROUTINE: STARTR
	This subroutine is used to calculate an approximation WW to the solution to be found by the Fibonacci search. The values IL and TU for the end points of the search interval are set using WW.

```
      SUBROUTINE STARTR(WW)
      COMMON/CALCOM/E(7,8),C(65,8),REC(65),CAN(65),ENL(65,8)
      COMMON/SIZE/MAXSTA,JTYPES,KTERMS,NCREGN
      COMMON/COST/FIXCST,RECOST,CANCST
      COMMON/RTSIDE/ RSIDE(50)
      COMMON/NEWCO/IB,IE,ICOUNT,FLAGRM(50),RSIDER(50),RSIDEC(50)
      COMMON/SETB/B(65,8)
C *** CALCULATES INITIAL VALUE OF LAGRANGE MULTIPLIER FOR SETTING SEARCH
C *** INTERVAL END POINTS ***
      SUM = 0.0
      DO 20 J=1,JTYPES
      SUM1 = 0.0
      DO 10 I=IB,IE
   10 SUM1 = SUM1 + B(I,J) * REC(I) ** E(6,J)
   20 SUM = SUM + E(6,J) * SUM1
      SUM1 = 0.0
      DO 30 I=IB,IE
   30 SUM1 = SUM1 + REC(I)
      WW = SUM / SUM1
      RETURN
      END
```

APPENDIX E

SYSTEMS IMPLEMENTATION CHAPTER FROM FINAL AMRRO REPORT

8.0 AMRRO SYSTEMS IMPLEMENTATION

GENERAL

Under the AMRRO Study, GRC has conducted research and development activity toward the establishment of an Army recruiting Market Information and Analysis System (MIAS). The system development portion of the Study has been conducted under Task V of the contract. The MIAS is comprised of a number of subelements which are integrated into an overall concept with the principal focus oriented toward providing market information and conducting recruiting analyses at the Army District Recruiting Command (DRC) level.

MIAS SYSTEMS DESCRIPTION

General

The research efforts associated with the development of the MIAS elements were conducted under Tasks I-IV of the AMRRO study and are described in Sections 4, 5, 6 and 7 of this report. The flow diagram shown in Fig. 8-1 depicts the basic elements that comprise MIAS. MIAS can be divided into three separate modules:

- A Market Information Preparation Module
- A Market Information Data Base Module
- A Market Analysis Module

Each element of the system is dependent upon the other elements. The market analysis activity cannot be conducted without established market information data; in like fashion, market information data serve no purpose unless utilized in a meaningful manner. The interrelationship of each element in the system with regard to which element feeds another element can be seen in Fig. 8-1.

Market Information Preparation Module

The primary function of the Market Information Preparation Module is to process raw market information data into a form suitable for analytical usage. Since the scope of market information related to Army non-prior service recruiting is so large, by necessity a large number of data sources must be accessed and a considerable amount of

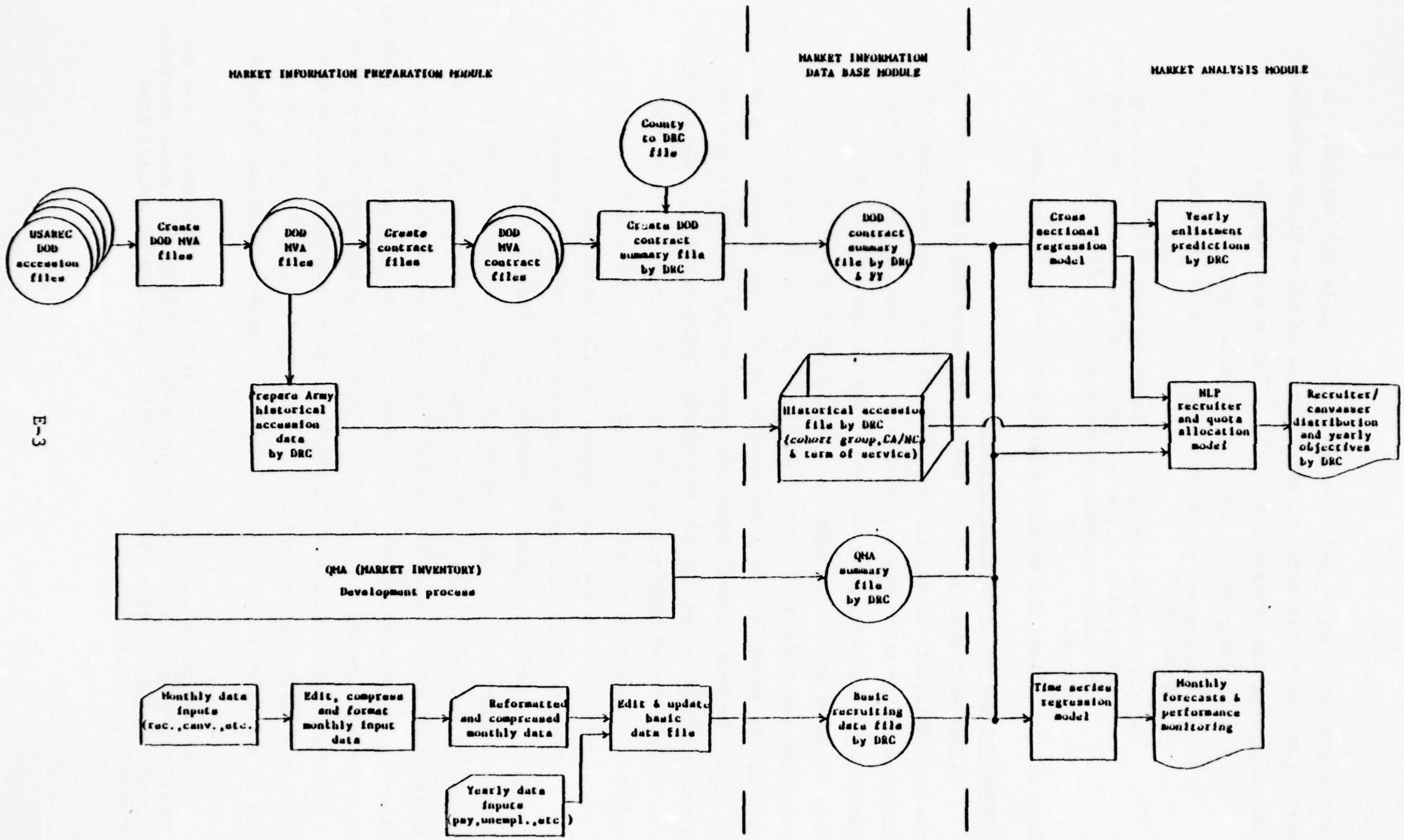

Fig. 8-1 — Flowchart of the Army Recruiting Market Information and Analysis System (MIAS)

data processing must be performed to obtain usable information. In particular, there are three primary processing flows which comprise the Market Information Preparation Module. They are as follows:

- Processing DOD and Army accession data
- Development of the Qualified Military Available (QMA)* inventory
- Creation of the Basic Recruiting Data file containing information on the utilization of recruiting resources and socio-economic conditions which affect recruiting success

Each of these flows are discussed in the following subsections.

Processing DOD and Army Accession Data

USAREC with the use of its Mechanized Reporting System (MRS) has the responsibility of maintaining DOD-wide data files on accession information for every non-prior service enlistee into each of the Services (i.e., Army, Navy, Air Force and Marine Corps). These data files on accessions contain a considerable amount of information regarding the numbers, locations and types of individuals entering each of the Services. In order to utilize this information as a part of MIAS, the basic USAREC files are first edited and compressed into a smaller file called the DOD MVA (Modern Volunteer Army) File where the superfluous or unneeded data elements are screened out of the individual accession records. The next step is the creation of a "contract" file from the consolidated DOD MVA (accession) File.

A "contract" is defined here as either a straight accession where the enlistee does not enter the Delayed Entry Program (DEP) or a DEP accession where the enlistee enters the DEP prior to actually accessing into one of the Services. For the DEP enlistee, two data records are contained on the USAREC files: a DEP record and an accession record. In order to avoid double counting, these two records are combined into a single record. The result of this processing step is to provide a DOD MVA Contract File which contains a record on every enlistee and the actual date when the enlistee signed the "contract" to enlist in one of the Services. The actual "contract" date is important because

*Subsequent to the conduct and preparation of this report, the QMA processing responsibility was transferred to MARDAC for annual operation. Therefore, this element of the MIAS will eventually be deleted from USAREC's responsibility.

that is when the individual makes his decision to join a Service rather than when he actually accessed into that Service.

The next step in the processing sequence is to create a DOD Contract Summary File by Army DRC boundaries. This process involves the consolidation of the individual contract records into a summary file containing contracts by Service, age, sex, race, education level, mental category and DRC location. A county Fips code to DRC cross-reference file is required to identify the DRC location.* The final step in the accession processing flow is to create a Historical Accession File by DRC to include accession breakouts by cohort categories, occupational specialities (i.e., combat arms options/non-combat arms), and term of service enlistment options. This is accomplished for any prescribed period of time from the DOD MVA File by utilizing only the accession records. It should be noted that the "contract" record cannot be utilized because it does not contain term of service data.

Development of the Qualified Military Available (QMA) Inventory

The QMA inventory represents the estimated number of people in the country within the 17-21 year age group that is both available and qualified to enlist in the military as of 1 July of a given year. For a detailed discussion of the QMA processing cycle refer to Section 4.0 of this report.

Preparation of The Basic Recruiting Data File (BRDF)

The third component of the Market Information Preparation Module involves the creating and updating of the Basic Recruiting Data File (BRDF). This file contains time-series data describing allocation of recruiting resources (e.g. recruiters on station, canvassers on station, etc.) and socio-economic conditions affecting recruiting success (e.g. unemployment rates and attitudes toward the military). The BRDF includes both monthly and yearly data elements. It is easily expanded to accommodate additional data items. The remainder of this sub-section will describe the design, contents and maintenance of the BRDF.

---

*The process of allocating other service contracts to Army DRC boundaries has not been performed because the inclusion of the Fips code is a recent change in the content of the accession records.

BRDF Design

The Basic Recruiting Data File shown in Figure 8-2 is a hierarchial file containing four levels of data:

- Level 1 -- DRC identifier
- Level 2 -- monthly data
- Level 3 -- yearly data (non-cohort oriented)
- Level 4 -- yearly data (cohort oriented)

For ease of processing, the length of each data record is taken to be 80 characters.

Further data may be accommodated in the file by defining additional fields in the current structure or by defining additional levels and/or cards per level.

BRDF Contents

The data fields currently defined are described in Tables 8-1a through 8-1f. The precise definition for most fields is given elsewhere in this report and merely referenced in the tables.

A group of data elements not discussed elsewhere involve other service recruiters on station in an Army DRC. The methods used to estimate these elements are discussed below.

Air Force: Data available from the Air Force showed the number of recruiters assigned to each of seven regions by month for fiscal years 1972-5. The problem was to determine the percentage of the Air Force regional staff operating in each Army DRC, since every service has a different geographic organization. An Air Training Command manual* gave the location of each Air Force recruiting office and the number of recruiters assigned to it. Thus, it was possible to calculate by hand the number of Air Force recruiters whose offices were located within the boundaries of each Army DRC and to determine each DRC's "share" of the Air Force regional recruiting staff. Eight Army DRCs straddled Air Force regional boundaries; therefore, the number of Air Force recruiters for

*ATC Manual 23-3

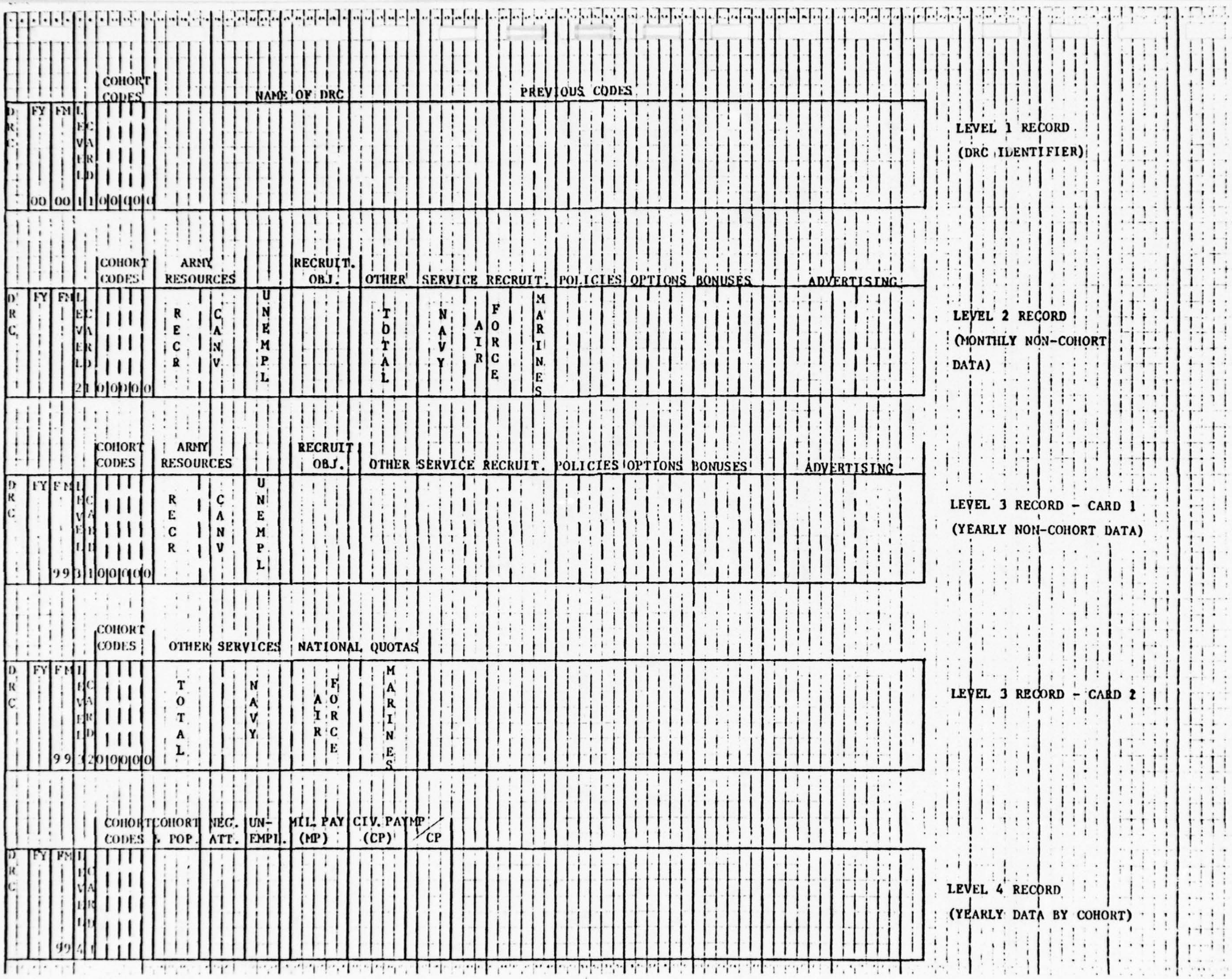

Fig. 8-2 -- Basic Recruiting Data File Design

Table 8-1a

BASIC RECRUITING DATA FILE LAYOUT -- LEVEL 1

Columns	Data Element	Description/Definition
1-2	DRC Code	
3-4	Fiscal Year	Zero-filled
5-6	Fiscal Month	Zero-filled
7	Level	1
8	Card	1
9-13	Cohort Codes	Zero-filled
14-43	Name of DRC	
44-58	Previous DRC Codes	
59-80	Undefined	

Table 3-1b

BASIC RECRUITING DATA FILE LAYOUT -- LEVEL 2

Columns	Data Element	Description/Definition
1-2	DRC Code	
3-4	Fiscal Year	
5-6	Fiscal Month	
7	Level	2
8	Card	1
9-13	Cohort Codes	Zero-filled
14-17	Recruiters on Station	As described
18-21	Canvassers on Station	As described
22-25	Unemployment Rate	As described
26-31	Recruiting Objective	
32-36	Total other Service Recruiters	
37-40	Navy Recruiters	
41-44	Air Force Recruiters	
45-48	Marine Recruiters	
49-50	POB1	As described in Table 8-1f
51-52	POB2	"
53-54	POB3	"
55-56	POB4	"
57-58	POB5	"
59-60	POB6	"
61-62	POB7	undefined
63-64	POB8	undefined
65-66	POB9	undefined
67-68	POB10	As described in Table 8-1f
69-74	Advertising Data	undefined
75-80	Advertising Data	undefined

Table 8-1c

BASIC RECRUITING DATA FILE LAYOUT -- LEVEL 3, CARD 1

Columns	Data Element	Description/Definition
1-2	DRC Code	
3-4	Fiscal Year	
5-6	Fiscal Month	99
7	Level	3
8	Card	1
9-13	Cohort Codes	Zero-filled
14-17	Recruiters on Station	Sum of monthly data
18-21	Canvassers on Station	Sum of monthly data
22-25	Unemployment Rate	Average of monthly data
26-31	Recruiting Objective	Sum of monthly data
32-36	Total Other Services Recruiters	"
37-40	Navy Recruiters	"
41-44	Air Force Recruiters	"
45-48	Marine Recruiters	"
49-50	POB1	Average of monthly data
51-52	POB2	"
53-54	POB3	"
55-56	POB4	"
57-58	POB5	"
59-60	POB6	"
61-62	POB7	undefined
63-64	POB8	undefined
65-66	POB9	undefined
67-68	POB10	Average of monthly data
69-74	Advertising Data	undefined
75-80	Advertising Data	undefined

Table 8-1d

BASIC RECRUITING DATA FILE LAYOUT -- LEVEL 3, CARD 2

Columns	Data Element	Description/Definition
1-2	DRC Code	
3-4	Fiscal Year	
5-6	Fiscal Month	99
7	Level	3
8	Card	2
9-13	Cohort Codes	Zero-filled
14-19	Total Other Service Quota	National, yearly figures
20-25	Navy Quota	"
26-31	Air Force Quota	"
32-38	Marine Quota	"
39-80	Undefined	

Table 8-1e

BASIC RECRUITING DATA FILE LAYOUT -- LEVEL 4

Columns	Date Element	Description/Definition
1-2	DRC Code	
3-4	Fiscal Year	
5-6	Fiscal Month	99
7	Level	4
8	Card	1
9-13	Cohort Codes	As described in Table 8-
14-17	Cohort/Population	As percent
18-21	Unfavorable Attitude	As percent of cohort
22-25	Unemployment Rate	As percent
26-30	Military Pay (MP)	
31-35	Civilian Pay (CP)	Average for cohort
36-39	MP/CP	As fraction
40-80	Undefined	

Table 8-1f

ARMY POLICIES, OPTIONS AND BONUSES

Identifier	Description
POB1	This variable is positive for months when recruiter credit was not given for category III, non-high school graduate enlistees and 0 for all other months. It was initialized at 1.0 and scaled down to 0.3 to represent the gradual withdrawal of the policy.
POB2	This variable is positive when a maximum high school graduate recruiting policy is in effect and 0 otherwise. The withdrawal of the policy is modeled by a ramp.
POB3	This variable is set to 1.0 for July and August of 1970 during which time the Army restricted two-year enlistments. The variable is set to zero otherwise.
POB4	This variable is set to 1.0 during the time when the 2-year travel and training option was offered to potential enlistees. The variable is set to zero otherwise.
POB5	This variable is set to 1.0 when the $1500 bonus was in effect for combat arms enlistees and to zero for all other periods.
POB6	This variable is set to 1.0 when a $2500 bonus was being paid combat arms enlistees who were high school graduates. The variable is set to zero otherwise.
POB10	This variable is set to 1.0 for the first quarter of FY76. During this time, no 17-year old enlistees were accepted. The variable is set to zero otherwise.

them was computed by adding fractions of two different recruiting groups. Beckley DRC, for example, had 6.4% of USAF Group 3502 recruiters and 1.6% of USAF Group 3503 recruiters. It was assumed that these percentages, based on a November 1973 publication, were constant over the last few years.

Example: 43 recruiters listed from USAF Recruiting Group 3503 were assigned to the 19 offices of Detachment 303, with headquarters in Coral Gables, Fla. Of these, 13 offices with 19 recruiters were inside the boundaries of Army's Miami DRC and 6 offices with 14 recruiters were located inside the Army's Jacksonville DRC. Also operating inside the boundaries of the Jacksonville DRC were 26 Air Force recruiters from detachment 302. So Jacksonville DRC had a total of 40 recruiters of the 268 listed for the region, or 14.9%. This share of the total strength of USAF Group 3503 gave Jacksonville 55 Air Force recruiters in September 1971, 69 in April 1975, etc.

Navy and Marine Corps: More assumptions about the geographical distribution of Navy and Marine recruiters had to be made than were necessary for the Air Force recruiters, since the detailed cross sectional data on the office address of each recruiter were only available from the Air Force. The figures from the Navy and Marine Corps were more detailed than those from the Air Force in one sense (the Air Force gave the staffing levels for each of seven regions), while the Marine Corps gave levels for each of 48 recruiting stations and the Navy for each of 44 recruiting districts. The problem and the solutions for handling the Navy and Marine Corps figures were the same: how to "map" 48 or 44 stations into 64 Army DRCs.* An additional problem was posed by the fact that the Navy recruiting district boundaries changed every year, there being 37 districts in FY 1971 and 44 in FY 1975.

In rare cases, the boundaries of different service recruiting districts coincided: USMC RS Los Angeles, for example, covered the same area as USAREC DRC Los Angeles. In most cases, though, districts overlapped.

---

*If recruiters were identified on a county basis the problem would be eased considerably.

The amount of overlap was estimated by dividing the number of counties in the USMC district which were inside the boundaries of a particular USAREC DRC by the total number of counties in the USMC district. The resulting percentage was taken to be that DRC's share of the USMC district's recruiting staff.

Example: USMC's Denver district covers 107 counties in 4 states. Of these, 11 were in the Army's Sioux Falls DRC and 96 (approximately 90%) in the Army's Denver DRC. The Denver DRC also covers territory assigned by the Marine Corps to their Omaha and Kansas City districts: the Denver DRC share was 6% and 10%, respectively. Therefore, the number of USMC recruiters operating in the Army's Denver DRC during FY 1975 was obtained by adding 90% of the USMC Denver staff, 6% of USMC Omaha staff, and 10% of USMC Kansas City staff (33 + 2 + 5 = 40).

The important assumption which had to be made was that Marine and Navy recruiters were distributed fairly uniformly over the counties they served. In cases like the Denver example, it was felt that the large number of counties and the addition of figures from several districts would tend to even out the error introduced by this necessary assumption. Some of the Navy districts, though, had a relatively small number of counties, with suburban and rural counties located in a different Army DRC from the urban counties. In these cases, an assumption that the rural or suburban county in one Army DRC had as many Navy recruiters as the urban county in another DRC would be a significant source of error. To avoid underestimating the number of Navy recruiters in certain metropolitan areas (including Boston, New York, Philadelphia, Washington, Detroit, Chicago, and Los Angeles), urban counties or boroughs were weighted double.

The figures which resulted for the numbers of Navy and Marine Corps recruiters in the Army districts were felt to be accurate enough to reflect changing force levels and geographic distribution of recruiters. It was not felt that the precision implied by monthly figures was warranted; therefore, annual average numbers of recruiters were used in these calculations.

BRDF Maintenance

The Basic Recruiting Data File Maintenance System is depicted schematically in Figure 8-3. It consists of a primary processor (BRDF-FMP) and a supporting processor to aid in data preparation (BRDF-MUG). The functions of these programs, their input requirements and their outputs are discussed below.

BRDF-FMP: File Maintenance Program. This program performs the following maintenance functions:

- Edit input data (in excess of 100 edit functions are provided
- Add edited data to file
- Create summary data elements (totals and quotients) and summary data records (Level 3, card 1 records) as available data permits
- Insure consistency of data by revising summary data elements and summary data records to reflect a change to any component thereof and by prohibiting inconsistent specifications of a summary item
- Delete individual records (and automatically any summary record constructed therefrom)
- Delete all records for a given year
- Provide edit reports describing any errors detected in input data and detailing all changes made to BRDF

Yearly data are prepared manually in the appropriate format. Monthly data are prepared separately for each monthly data element and submitted to BRDF-MUG for editing and formatting.

BRDF-MUG: Monthly Update Generator. This program accepts up to 12 monthly values for a data element in the format of Figure 8-4, edits the data and outputs the data in the level-2 record format required by BRDF-FMP. When data for more than one element are provided, the data for all elements appear on the same output record. For example, suppose that data are individually prepared as per Figure 8-4 for recruiters on station, unemployment and recruiting objectives. When these three data sets are submitted to BRDF-MUG, a single level-2 record containing the appropriate values for recruiters, unemployment and recruiting objective is produced for each DRC and each month in the period under consideration. BRDF-MUG produces an edit report which describes any errors in the input data and lists the output records so as to facilitate verification of input to BRDF-FMP.

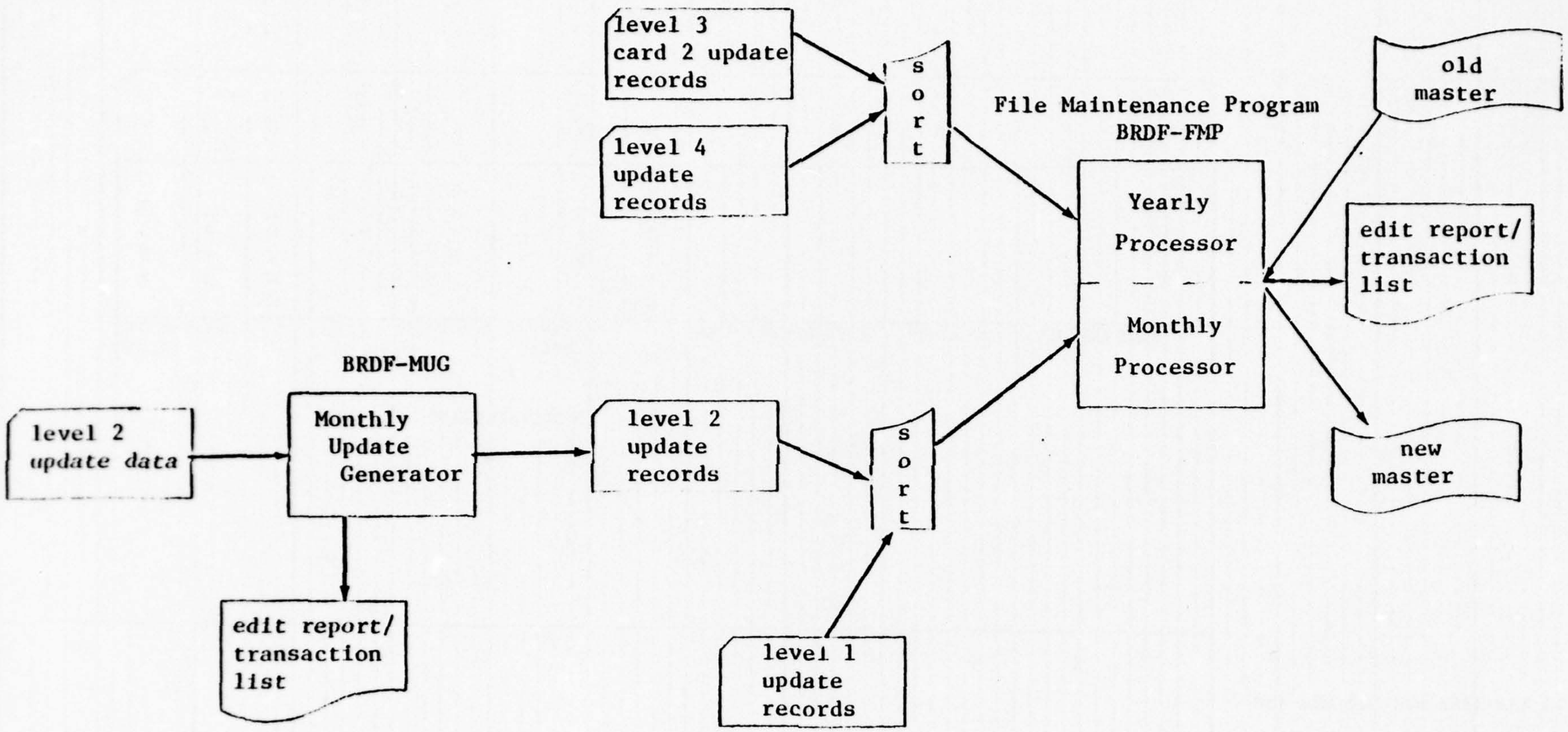

Fig. 8-3 — USAREC Basic Recruiting File Maintenance System

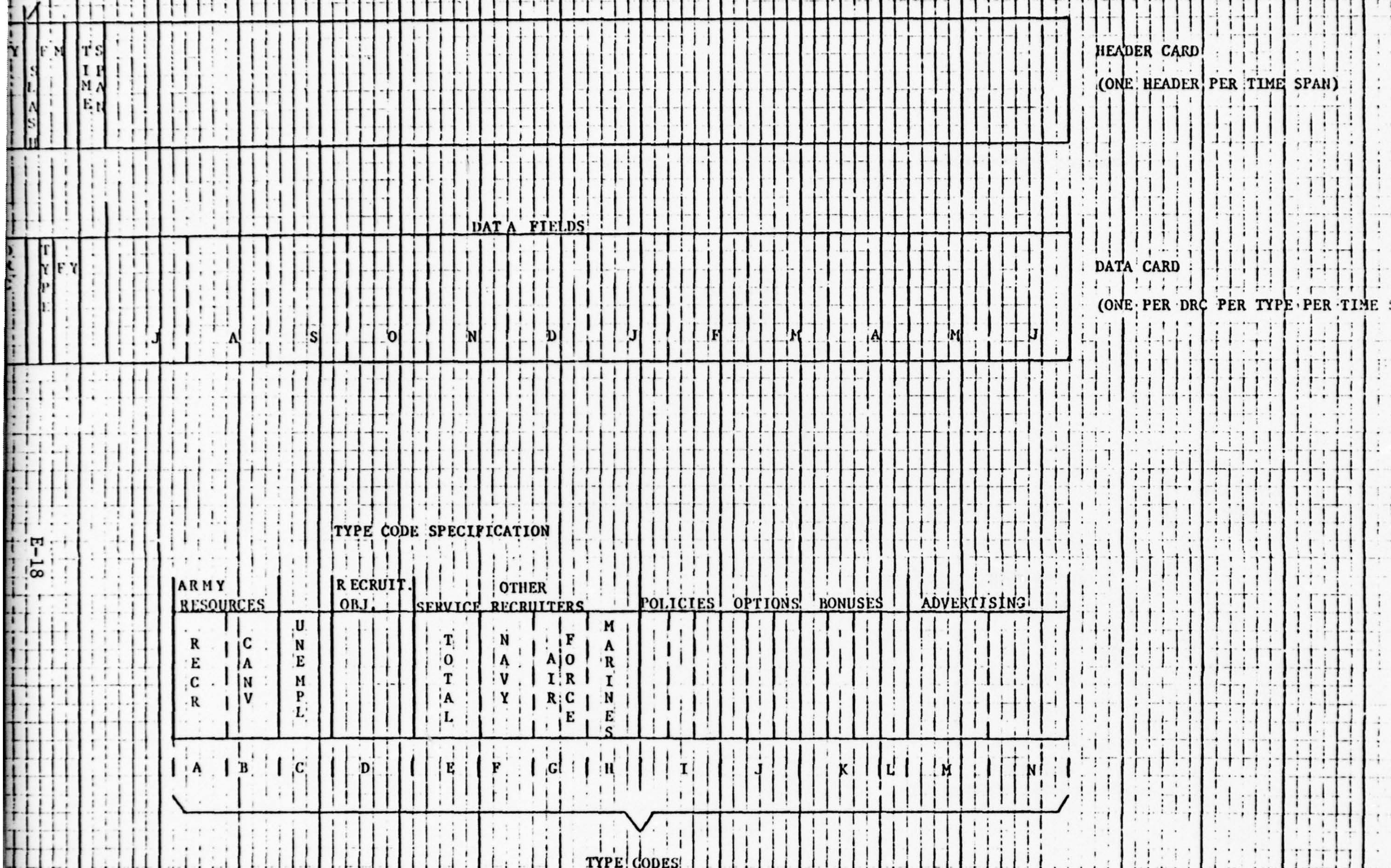

Fig. 8-4 — Format for Monthly Update Cards

Market Information Data Base Module

As shown in Fig. 8-1, there are four data files which comprise the Market Information Data Base Module:

- The DOD Contract Summary File by DRC
- The Historical Accession File by DRC
- The QMA Summary File for DRC
- The Basic Recruiting Data File by DRC

Each of these files must be maintained, updated, and accessed on an as-required basis. Each file with the exception of the Historical Accession File will be, for the present, maintained on magnetic tapes. The Historical Accession File will be maintained in punched card form. Subsequent usage could be made of a generalized data base package which would place these files on a computer disk pack.

The first three files will, most likely, be updated only on an annual basis. The Basic Recruiting Data File will most likely be updated on a quarterly basis. The process of accessing these files for analytic purposes will be on an as-required basis.

Figures 8-5 through 8-7 present the format layouts of the first three base files, respectively. Table 8-2a describes the cohort groupings displayed in Figs. 8-5 and 8-7. Table 8-2b describes the cohort groupings displayed in Fig. 8-6. The Basic Recruiting Data File layout was previously shown in Fig. 8-4.

Market Analysis Module

The Market Analyses Module of MIAS is comprised of three computer models:

- A Cross-Sectional Regression Model
- A Time-Series Regression Model
- An Optimal Recruiter Allocation Model (ORAM)

Each of these models draws upon a combination of the Market Information Data Base files designated in the previous section for their basic data inputs.

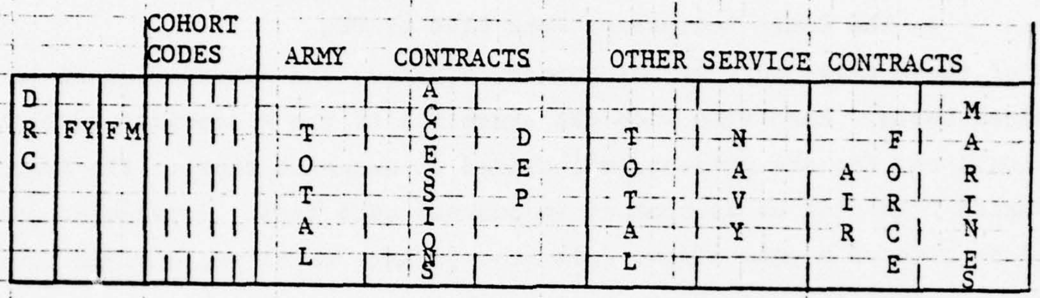

Fig. 8-5—DOD Contract Summary File Layout

					FRACTIONS OF ACCESSIONS BY COHORT									TOTAL ACCESSIONS	
DRC		DRC IND	REGION	ENLOPT	TERMSER	HSG BLACK 1-3A	HSG WHITE 1-3A	HSG BLACK 3B-4	HSG WHITE 3B-4	NHSG BLACK 1-3A	NHSG WHITE 1-3A	NHSG BLACK 3B-4	NHSG WHITE 3B-4			

Fig. 8-6—Historical Accession File Layout

		COHORT CODES								
DRC	FISCAL YEAR						TOTAL DRC POP.*	MA POP.*	COHORT/ TOTAL QMA POP	COHORT/ TOTAL HIGH SCHOOL SENIORS

*Zero filled except on DRC Summary Record/Sex and Race

Fig. 8-7—QMA Summary File Layout

Table 8-2a

COHORT CODING KEY FOR BASIC RECRUITING DATA FILE,

QMA SUMMARY FILE

Code	Group/Class
	<u>Sex Group</u>
1	Male
2	Female
	<u>Age Group</u>
1	17-21 years
2	22-24 years
	<u>Racial Group</u>
1	White
2	Black
3	Other
	<u>Educational Categories</u>
1	High school graduates - in school
2	High school graduates - not in school
3	Non-high school graduates - in school
4	Non-high school graduates - not in school
5	All including unfit
	<u>Mental Categories</u>
1	I
2	II
3	IIIA
4	IIIB
5	IVA
6	IVB
7	All including V

Table 8-2b

COHORT CODING KEY FOR CONTRACT SUMMARY FILE

Code	Group/Class
	Sex Group
1	Male
	Age Group
1	17-21 years
2	All others
	Racial Group
1	All except black
2	Black
	Educational Categories
1	High school graduate
2	Non-high school graduates
	Mental Categories
1	I - IIIA
2	III B
3	All others

The first two models are utilized to conduct analyses to determine which factors (i.e., recruiting resources and socio-economic) affect recruiting success and the respective influences of these factors in achieving Army accessions. The cross-sectional model is utilized to examine variation in factors among Army DRCs for a specified time period, and the time series model is utilized to examine variations in factors affecting recruiting over time.

The third model is utilized to determine the optimal placement of recruiters and canvassers among DRCs based upon projected socio-economic conditions and specified accession requirements and, subsequently, to determine DRC objective allocations based upon the optimal placement of recruiters and canvassers.

Cross-Sectional Regression Model

The cross-sectional regression model is a mathematical regression technique which is utilized to examine the variations in Army accessions versus those factors which are believed to influence Army accessions across geographical areas of the country for a given time period. For the purposes of Army market analyses, the geographical boundaries have been specified to be the established Army DRC areas. Typical recruiting factors to be analyzed will include:

- Recruiters on production
- Attitudes toward the military/Army
- Size of the QMA inventory
- Unemployment rate
- Advertising
- Others

Each of these factors and others will be analyzed to determine which factors explain the variations in accessions among DRCs. The supply

equation which best explains the geographical accession patterns (adhers to valid statistical regression requirements and is historically consistent with empirical recruiting results) is selected as the cross-sectional supply model to determine enlistment propensities by DRC. Additionally, the elasticities of the independent variables are utilized as a fundamental input to the recruiter allocation model.

The data input requirements for the cross-sectional analysis are derived from:

- the DOD Contract Summary File
- the QMA Summary File
- the Basic Recruiting Data File

The DOD Contract Summary File provides historical data on Army accessions by DRC which is the dependent variable in establishing the cross-sectional model. The QMA Summary File and the Basic Recruiting Data File provide the data for the independent variables. No other external data sources are required. If a new independent variable is to be analyzed, the historical data stream must be added to the Basic Recruiting Data File.

The cross-sectional regression model utilized the generalized time-series processor (TSP) computer software package which is designed specifically for regression modeling.

Time-Series Regression Model

The time-series regression model is much the same as the cross-sectional model with the exception that variation in accessions vs recruiting factors are analyzed over a series of time periods rather than for a given time period. The objective of this analysis is to identify the influence of recruiting factors over time. One of the advantages of this type of analysis is that shorter time periods can be examined (i.e., monthly, quarterly or semi-annual time periods).

The data sources for the time-series model are the same as those for the cross-sectional model. In addition, the computer software package utilized in the time-series modeling is the UCLA-developed BIO-MED package.

It is anticipated that the time series model will be utilized for monthly forecasting and that actual accession data will be matched against forecasted accessions as an operational capability of the time series model.

Optimal Recruiter Placement and Objectives Allocation Model

The final, and perhaps most important, computer model of MIAS is the optimal recruiter allocation model (ORAM). The optimization model consists of a series of nonlinear equations which must be solved to achieve an optimum solution. The primary equation relies on a form of the enlistment supply equation developed from the cross-sectional regression analysis. The supply equations are the objective function of the model with the projected USAREC recruiting budget being minimized by varying recruiter and canvasser levels at each DRC, subject to overall national accession requirements. The solution results in the optimal placement of recruiters and canvassers among the DRCs that yields the largest number of accessions at the least cost. However, since other factors such as term of service, occupational specialty, and cohort specific requirements are essential considerations in establishing recruiting objectives, the objective function described above is constrained by additional equations to ensure that the solution satisfies these additional goals.

DEVELOPMENT FEASIBILITY AND INITIAL USAREC ADP IMPACT

General

The research effort conducted under the AMRRO Study has centered around the development of each of the elements of MIAS. During the course of the study, preliminary methodology reports were written which described the technical approaches to be followed. Subsequent activity was directed toward the actual data collection, computer programming and testing of each of the MIAS elements.

MIAS Development Feasibility

The development of MIAS has shown that each element of MIAS is technically sound and achievable within practical limits of development.

However, data collecting, data processing, and computer modeling processes associated with recruiting activity can undergo continuing refinement and improvement over time; as new information is uncovered, new opportunities arise for refinement in the systems design. Since resources and time are not unlimited, it has been necessary to place limitations on the scope of GRC activity and to work with controlling assumptions to proceed with the development of the basic MIAS elements. In this regard, the AMRRO study team has placed primary emphasis on achieving a fundamentally sound overall MIAS capability which will be of immediate use to USAREC management and which is additionally suitable for refinement and expansion over the long term.

At the initiation of the AMRRO study, the feasibility of conducting market analyses in the form of regression and optimal allocation modeling at the DRC level was unknown. GRC's work indicates that working at the DRC level is both feasible and practical for the cross-sectional analysis model and ORAM. In the case of the time-series analysis, given the availability of accession data, regional analysis appears to be the lowest practical level of analysis at this time. The usefulness of conducting analyses at the DRC and regional levels is readily apparent, because it allows USAREC management to examine recruiting activity at a finer level of detail than was available previously.

In summary, the feasibility of developing each of the MIAS elements has been successfully established. It is further recognized that the system under operational development will undergo refinement, improvement, and probably expansion in succeeding years; however, the fundamental design of MIAS will provide a technically sound capability for immediate USAREC recruiting management analysis.

Anticipated Impact on USAREC ADP Operations

Some elements of MIAS are very straightforward and will have little impact on USAREC ADP operations; other elements are complex and will require implementation planning and training to achieve an effective USAREC operational capability.

Impact of the Market Information Preparation Module

As described earlier there are three basic data flows associated with this MIAS module. The first data flow, the processing associated with the creation of the DOD Contract Summary File and the Historical Accession File, is relatively straightforward and is comprised of four to five computer programs. The data processing associated with this data flow involves processing large tape files with a substantial amount of input/output processing; because of this, the computer programs have been written in COBOL. It is anticipated that this processing cycle will be performed quarterly and will require approximately one hour of CPU time and eight hours of wall clock processing time per cycle. Currently, this flow is being run on the CDC 6400 computer at GRC. Only minor problems are anticipated in converting this processing cycle to a UNIVAC 1108 computer; however, substantial documentation will be required to permit USAREC personnel to independently operate this processing cycle.

The second data flow is concerned with the development of the QMA inventory report output and summary file.* As shown in Fig. 4-1, this processing flow is complex and lengthy. In fact, Fig. 4-1 is a simplification of the actual processing requirements. In addition, there are three data sources associated with this flow which should be updated periodically:

- The ten-year Census data, 1/100, 5 & 15% County Group and 5% State Public Use Samples (PUS)
- The yearly P-25/26 series Census migration reports
- The yearly "Cause of Death" summary tapes for mortality data

Each of these data sources is not complex in themselves; but a thorough understanding of the entire processing cycle will be required to keep the QMA processing cycle updated and operational. It is envisioned that this processing cycle will be run annually.

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*Note that the responsibility for this processing flow has been transferred to MARDAC.

The computer programs associated with this cycle are written in FORTRAN IV and are operational on an IBM 360/370 computer. However, some of the subroutines within the computer programs are written in machine-oriented language because of the complexity of the processing routines. For example, in order to avoid excessive round-off errors due to the IBM word-size characteristics, double word boundaries had to be used in many cases. In addition, when processing the multiple reel Census tape inputs, a special machine-oriented subroutine was utilized to reduce excessive processing times.

The QMA processing cycle is comprised of approximately thirty-six computer programs which will utilize approximately eight hours of CPU time and approximately twenty hours of wall clock processing time. It is believed that substantial UNIVAC 1108 conversion, personnel orientation and detailed documentation will be required for USAREC representatives to operate this data flow on an independent basis.

The final data flow of the Market Information Preparation Module involves the creation and updating of the Basic Recruiting Data File. This process is relatively straightforward and is not extensive. There are two computer programs, written in COBOL, associated with this flow. They are currently operational on GRC's CDC computer, and conversion to the UNIVAC 1108 should be relatively easy. However, documentation is required to achieve an independent USAREC operational capability.

It is anticipated that this processing flow will be run on a quarterly basis with a small additional amount of processing required at the end of the fiscal year. The yearly CPU time is anticipated to be approximately 30 minutes and wall clock processing time about 2 hours. The data inputs to this processing flow would be prepared manually on punched cards by Market Studies and Analysis Office representatives.

Impact of the Market Information Data Base Module

This module consists of four data files, three of which are maintained on magnetic tapes and one of which is maintained in punched card form. The ADP impact of this module will be essentially nonexistent. It is anticipated that up to 10 years of historical data will be maintained in each file; a given year's data can either be contained on a single tape, or separate tapes can be created yearly.

If a decision is made to implement a generalized data base software package which utilizes computer disk files, there would be a more significant ADP impact; however, at this time such a decision is not planned.

Impact of the Market Analysis Module

The Market Analysis Module, consisting of two regression models and a nonlinear programming model, will have a larger functional impact on the Market Studies and Analysis Office operations than on USAREC's ADP operations. The two regression models utilize the generalized TSP and BIO-MED software packages, and ADP usage will depend upon the frequency with which these models are run. It is believed that the TSP and BIO-MED packages are compatible with the UNIVAC 1108 computer. Data inputs to TSP and BIO-MED can be either in punched card or magnetic tape form. A series of regression runs can be made on a single processing pass, and computer processing times are minimal. The total estimated CPU time over a given year is about three hours CPU time and about five hours wall clock processing time.

The major impact of the regression modeling would be experienced by the functional, operations research representatives who would be required to understand regression and statistics theory and to prepare the appropriate data inputs for the software packages. These data inputs are accessed from the data files maintained in the Market Information Data Base Module.

The ORAM is more complex than the regression models. This model is currently operational on GRC's CDC computer, and has been specially programmed for USAREC's application. The computer language utilized is FORTRAN IV; conversion requirements to make this model operational on the UNIVAC 1108 are unknown at this time. However, it is believed that conversion problems would only be minimal.

Substantial documentation will be required for USAREC representatives to modify and/or operate this NLP model. All data inputs are currently in punched card form and computer processing times are not extensive.

It is estimated that on a yearly basis two hours of CPU time and four hours of wall clock processing time will be sufficient to operate the model on an as-required basis.

As in the case of the regression models, the ORAM will require that operational research representatives on the functional side have a thorough understanding of the model in order to prepare the proper data inputs and to interpret output results.

IMPLEMENTATION SUMMARY

The Market Information and Analysis System (MIAS) developed by GRC is judged both feasible and practical. It is acknowledged that refinements, improvements and/or expansion in selected areas could be expected over time. However, the fundamental MIAS design will prove to be a very useful and viable system to recruiting management.

Impacts on USAREC operations will be two-fold: ADP impact and functional operations research impact. The ADP impact is summarized on Table 8-3; it is estimated that approximately 17.5 CPU hours and approximately 63 wall clock processing hours yearly would be required to operate MIAS. Conversion problems in utilizing the UNIVAC 1108 computer requirements will be substantial for the DOD Contract File processing flow, the QMA processing flow, and the NLP optimization model.

The functional operations research impact will result from two areas of MIAS: basic data collection, and the operation and understanding of the computer models.

In summary, implementation of MIAS will require an understanding of unique elements of the system by both the ADP and functional organizations at USAREC. The ADP impact of MIAS on USAREC operations should be relatively small in comparison with other information system requirements; however, it is believed that initial implementation will require conversion activity, substantial documentation, and user orientation. In order to achieve an annual operational capability it is recommended that a small, identified group of both ADP and functional representatives be established to maintain and operate the system on a continuing basis.

Table 8- 3

MIAS ADP IMPACT SUMMARY

MIAS element	Estimated number of computer programs	Computer language	Conversion problems	Documentation requirements	Yearly estimated CPU time	Yearly estimated wall clock processing time
• Market Information Preparation Module						
- DOD Contract file processing	4-5	COBOL	Minimal	Substantial	4 hrs	32 hrs
- QMA processing *	36	FORTRAN IV	Substantial	Substantial	8 hrs	20 hrs
- Basic Recruiting Data file processing	2	COBOL	Minimal	Moderate	.5 hrs	2 hrs
• Market Information Data Base Module	NA	NA	NA	NA	NA	NA
• Market Analysis Module						
- Cross-sectional and Time Series Regression Models	NA	TSP software package	Minimal	Minimal	3 hrs	5 hrs
- NLP Optimization Model	1	FORTRAN IV	Estimated—Minimal	Substantial	2 hrs	4 hrs
				Totals	17.5 hrs	63 hrs

*Responsibility for this data processing element transferred to MARDAC.

PRELIMINARY IMPLEMENTATION PLAN

Since all of the MIAS has essentially been developed, each individual portion or all portions could be implemented either concurrently or sequentially. However, to permit early utilization of the Market Analysis Module, it is recommended that the existing Market Information Data Base Module be implemented first; the Market Analysis Module, second; and the Market Information Preparation Module, last. The sequential schedule will permit early utilization of the analytical models with existing data files at minimal impact on other USAREC ADP operations. Such an approach should be advantageous to the ADP operation's representatives, because it is anticipated that they will be faced with a difficult schedule in converting existing operational activities to the newly installed UNIVAC 1108 system.

Given the implementation of the existing data base and analytical models, the three basic data streams associated with the Market Information Module can be implemented concurrently. In this regard, responsibility for the QMA data processing sequence has been transferred to MARDAC (OSD) and implementation of this sequence will be independent of the other elements of MIAS. To facilitate implementation and operations, it is recommended that USAREC identify specific individuals to have cognizant responsibility for each element of the MIAS operational and maintenance activity. Figure 8-8 presents a suggested implementation schedule for planning purposes.

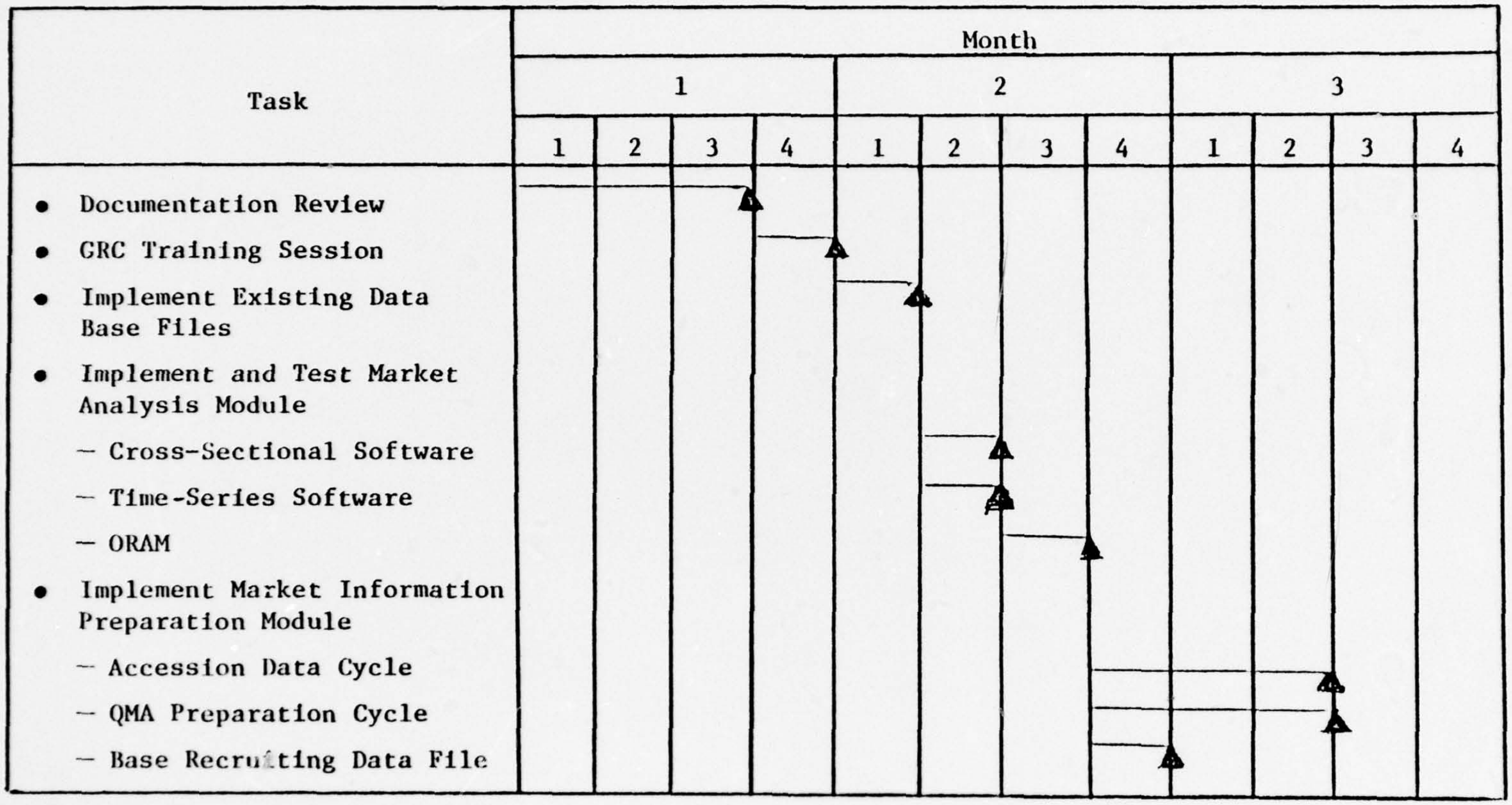

Fig. 8-8 — Preliminary Milestone Chart for MIAS Implementation

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